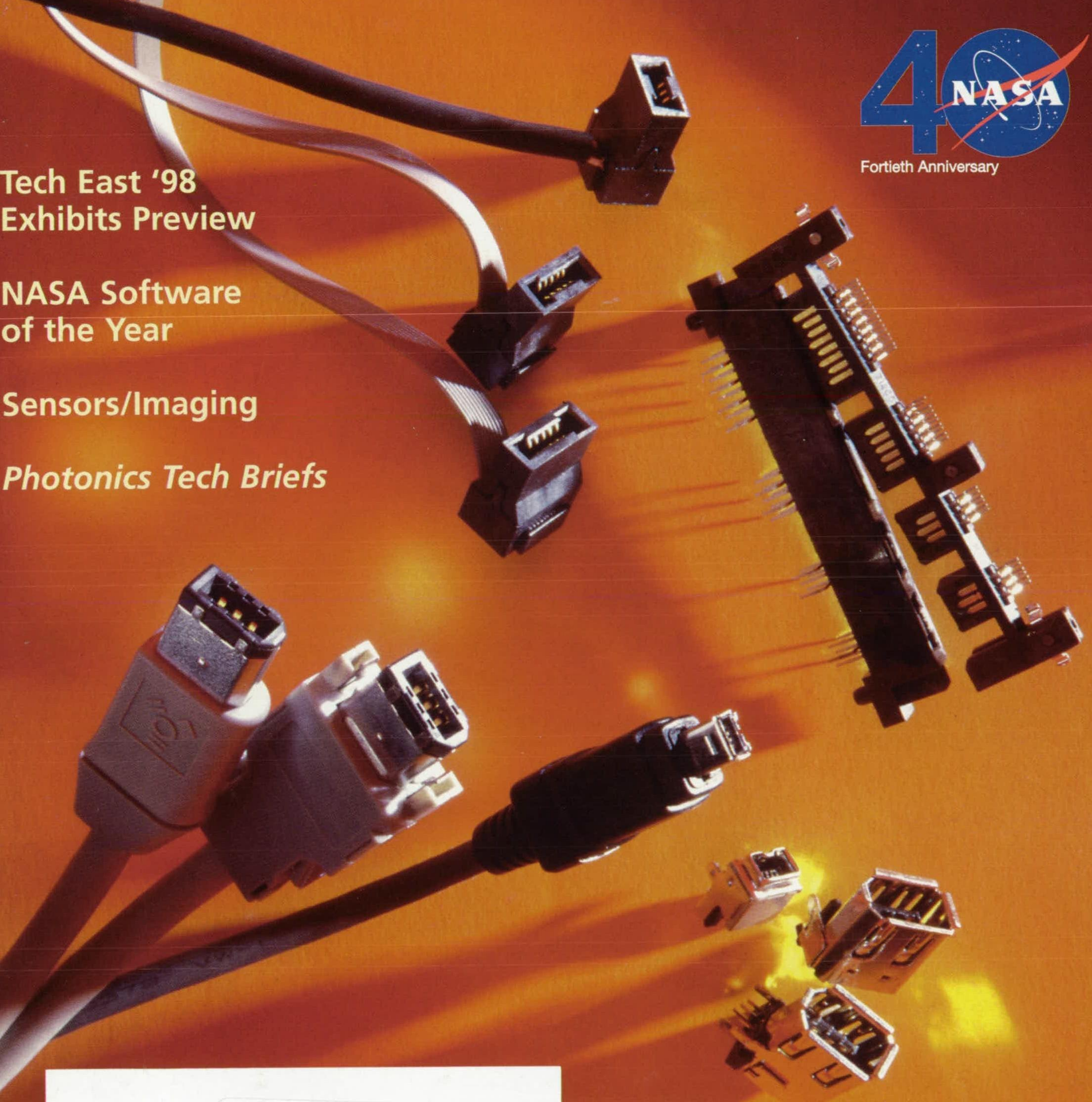
October 1998
Vol. 22 No. 10

# TECH BRIEFS

ENGINEERING SOLUTIONS FOR DESIGN & MANUFACTURING

Fortieth Anniversary



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TECH BRIEFS

October 1998 • Vol. 22 No. 10

## Features

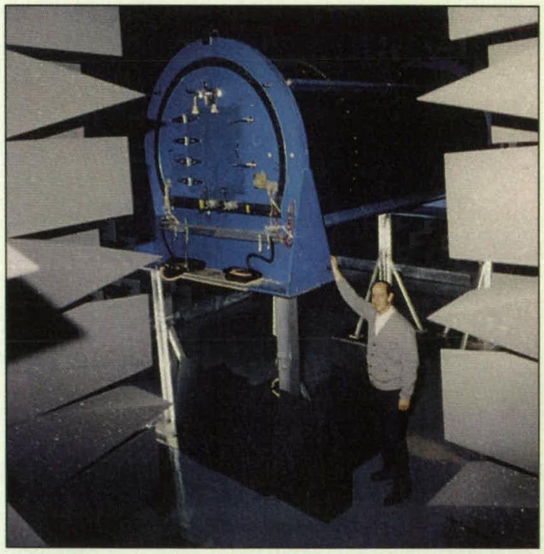


## Departments



## Briefs





*Dr. Ferdinand Grosveld of Lockheed Martin stands in the semi-anechoic test chamber at NASA's Langley Research Center in Hampton, VA. Used for acoustic testing of full-size and model aircraft structures, the chamber needed to meet strict sound-blocking requirements, while remaining light enough to be moved by an overhead crane. The 4,946 foam acoustic wedges for the partitions and floors were supplied by illbruck of Minneapolis, MN. Learn more about this sound solution in the Application Brief on page 32.*

(Photo courtesy of illbruck)

# Contents *continued*



## On the cover:

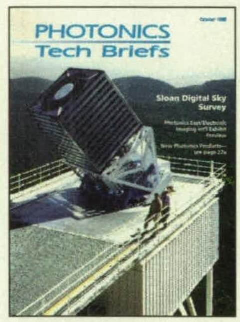
*Each month, New on the Market highlights new products available for design, engineering, and manufacturing in many different industries. This month's new products include serial I/O connectors from Molex (Lisle, IL) that meet the requirements of the IEEE 1394 standard, and feature metal shielding for ESD protection. For more information on the Molex connectors, and other innovative new products, see New on the Market, beginning on page 94.*

(Photo courtesy of Molex)

## Special Supplement



Follows page 32 in selected editions only.





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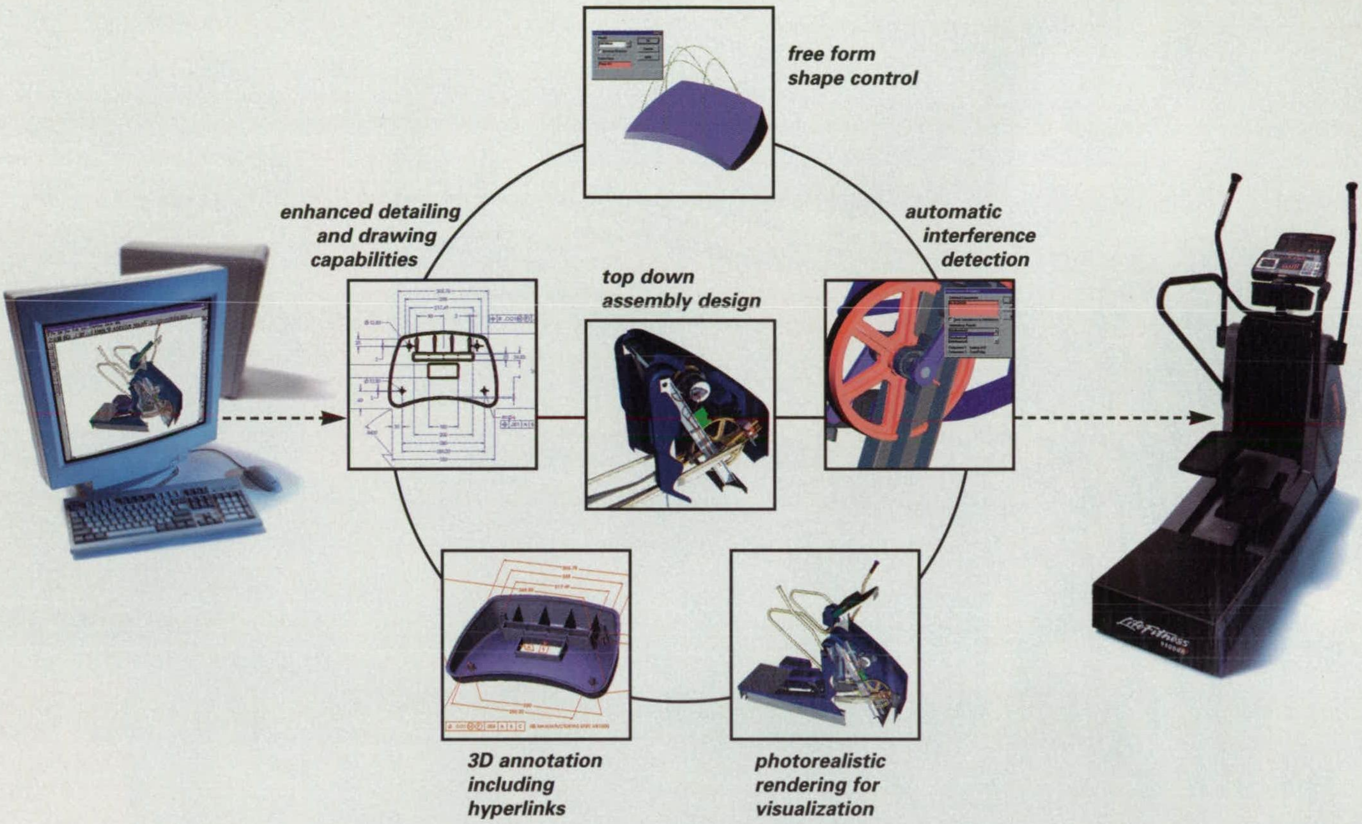


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## NASA Commercial Technology Team

*NASA's R&D efforts produce a robust supply of promising technologies with applications in many industries. A key mechanism in identifying commercial applications for this technology is NASA's national network of commercial technology organizations. The network includes ten NASA field centers, six Regional Technology Transfer Centers (RTTCs), the National Technology Transfer Center (NTTC), business support organizations, and a full tie-in with the Federal Laboratory Consortium (FLC) for Technology Transfer. Call (206) 683-1005 for the FLC coordinator in your area.*

## NASA's Technology Sources

If you need further information about new technologies presented in *NASA Tech Briefs,* request the Technical Support Package (TSP) indicated at the end of the brief. If a TSP is not available, the Commercial Technology Office at the NASA field center that sponsored the research can provide you with additional information and, if applicable, refer you to the innovator(s). These centers are the source of all NASA-developed technology.

**Ames Research Center**
Selected technological strengths: Fluid Dynamics; Life Sciences; Earth and Atmospheric Sciences; Information, Communications, and Intelligent Systems; Human Factors.
*Carolina Blake*
*(650) 604-0893*
*cblake@mail.arc.nasa.gov*

**Dryden Flight Research Center**
Selected technological strengths: Aerodynamics; Aeronautics Flight Testing; Aeropropulsion; Flight Systems; Thermal Testing; Integrated Systems Test and Validation.
*Lee Duke*
*(805) 258-3802*
*lee.duke@dfrc.nasa.gov*

**Goddard Space Flight Center**
Selected technological strengths: Earth and Planetary Science Missions; LIDAR; Cryogenic Systems; Tracking; Telemetry; Command.
*George Alcorn*
*(301) 286-5810*
*galcorn@gsfc.nasa.gov*

**Jet Propulsion Laboratory**
Selected technological strengths: Near/Deep-Space Mission Engineering; Microspacecraft; Space Communications; Information Systems; Remote Sensing; Robotics.
*Merle McKenzie*
*(818) 354-2577*
*merle.mckenzie@ccmail.jpl.nasa.gov*

**Johnson Space Center**
Selected technological strengths: Artificial Intelligence and Human Computer Interface; Life Sciences; Human Space Flight Operations; Avionics; Sensors; Communications.
*Hank Davis*
*(713) 483-0474*
*hdavis@gp101.jsc.nasa.gov*

**Kennedy Space Center**
Selected technological strengths: Environmental Monitoring; Sensors; Corrosion Protection; Bio-Sciences; Process Modeling; Work Planning/Control; Meteorology.
*Gale Allen*
*(407) 867-6626*
*galeallen-1@ksc.nasa.gov*

**Langley Research Center**
Selected technological strengths: Aerodynamics; Flight Systems; Materials; Structures; Sensors; Measurements; Information Sciences.
*Dr. Joseph S. Heyman*
*(804) 864-6006*
*j.s.heyman@larc.nasa.gov*

**Lewis Research Center**
Selected technological strengths: Aeropropulsion; Communications; Energy Technology; High Temperature Materials Research.
*Larry Viterna*
*(216) 433-3484*
*cto@lerc.nasa.gov*

**Marshall Space Flight Center**
Selected technological strengths: Materials; Manufacturing; Nondestructive Evaluation; Biotechnology; Space Propulsion; Controls and Dynamics; Structures; Microgravity Processing.
*Sally Little*
*(205) 544-4266*
*sally.little@msfc.nasa.gov*

**Stennis Space Center**
Selected technological strengths: Propulsion Systems; Test/Monitoring; Remote Sensing; Nonintrusive Instrumentation.
*Kirk Sharp*
*(228) 688-1929*
*ksharp@ssc.nasa.gov*

## NASA-Sponsored Commercial Technology Organizations

These organizations were established to provide rapid access to NASA and other federal R&D and foster collaboration between public and private sector organizations. They also can direct you to the appropriate point of contact within the Federal Laboratory Consortium. To reach the Regional Technology Transfer Center nearest you, call (800) 472-6785.

Joseph Allen
**National Technology Transfer Center**
(800) 678-6882

Ken Dozier
**Far-West Technology Transfer Center**
University of Southern California
(213) 743-2353

Dr. William Gasko
**Center for Technology Commercialization**
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**NASA ON-LINE:** Go to NASA's Commercial Technology Network (CTN) on the World Wide Web at **http://nctn.hq.nasa.gov** to search NASA technology resources, find commercialization opportunities, and learn about NASA's national network of programs, organizations, and services dedicated to technology transfer and commercialization.

## NASA Program Offices

At NASA Headquarters there are seven major program offices that develop and oversee technology projects of potential interest to industry. The street address for these strategic business units is: NASA Headquarters, 300 E St. SW, Washington, DC 20546.

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**Small Business Innovation Research Program (SBIR) & Small Business Technology Transfer Program (STTR)**
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## NASA's Business Facilitators

NASA has established several organizations whose objectives are to establish joint sponsored research agreements and incubate small start-up companies with significant business promise.

Dr. Jill Fabricant
**Johnson Technology Commercialization Center**
*Houston, TX*
*(713) 335-1250*

Wayne P. Zeman
**Lewis Incubator for Technology**
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*(216) 586-3888*

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If you are interested in information, applications, and services relating to satellite and aerial data for Earth resources, contact: Dr. Stan Morain, **Earth Analysis Center,** (505) 277-3622.

# UpFront

Product of the Month

The PenCAT/Pro™ 3D pen with force feedback from Haptic Technologies, Montreal, Quebec, Canada, enables CAD designers and 3D modelers to "feel" objects on the computer screen. Users can feel curves, edges, and surface textures of the objects they are designing, and the system can be used to replay motions directly to the user's hand. The system software development packages allow developers to build a new layer of information — the HUI (Haptic User Interface) — which describes how the objects feel to the sense of touch. The software is combined with the PenCAT/Pro peripheral, and is bundled with add-ons and plug-ins for a variety of CAD and 3D design applications. The system also can be used for data and medical visualization, and simulation applications.

**For More Information Circle No. 787**

## Storm Watch

In order to better understand and improve ground-based predictions of hurricanes, two specially equipped NASA aircraft took to the skies to collect high-altitude information about Atlantic storms. The Convection and Moisture Experiment (CAMEX) mission, conducted in August and September, yielded information on hurricane structure, dynamics, and motion, leading to improved hurricane prediction. Results also will be used to validate existing measurements from the Tropical Rainfall Measuring Mission of hurricanes and tropical storms, and to develop mathematical models for future Earth science missions.

Led by the Atmospheric Dynamics and Remote Sensing program at NASA Headquarters, the experiment should provide results that could increase warning time and decrease the size of evacuation areas. "We only know what goes on in the bottom half of a hurricane — from sea level to 27,000 feet," said Robbie Hood, an atmospheric expert with the Global Hydrology and Climate Center at NASA's Marshall Space Flight Center. "Now we can learn about these storms from top to bottom."

When a hurricane or tropical storm erupted in the Atlantic — such as Hurricane Bonnie in late August — a NASA DC-8, equipped with instruments to measure the storm's intensity and tracking, flew into the storm at 35,000 to 40,000 feet. At the same time, a high-altitude research plane soared above the storm at 65,000 feet to measure it from above. A ground research team launched weather balloons and monitored land-based sensors to validate the aircraft measurements.

*For more information, contact Tim Tyson of NASA Marshall at 205-544-0994.*

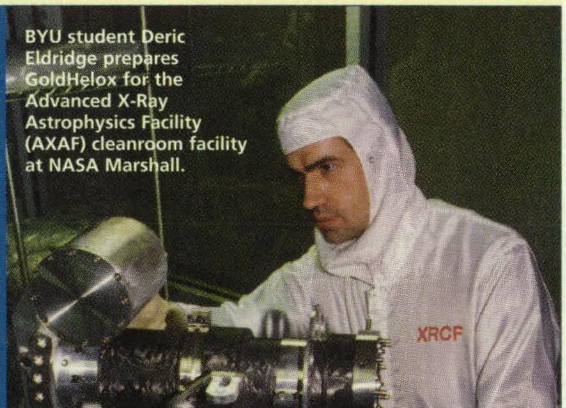
## Solar Study

The Sun impacts life on Earth by providing warmth and illumination. It also is a source of radio and electromagnetic emissions that can affect radio transmissions, broadcast and cable TV reception, and telephone communications. Variations in solar activity affect our climate and weather, the intensity of storms, droughts, and the ozone hole. Engineers at NASA Marshall have teamed with students and faculty at Brigham Young University (BYU) in Provo, UT, to test an inexpensive telescope that will study x-ray emissions from the Sun.

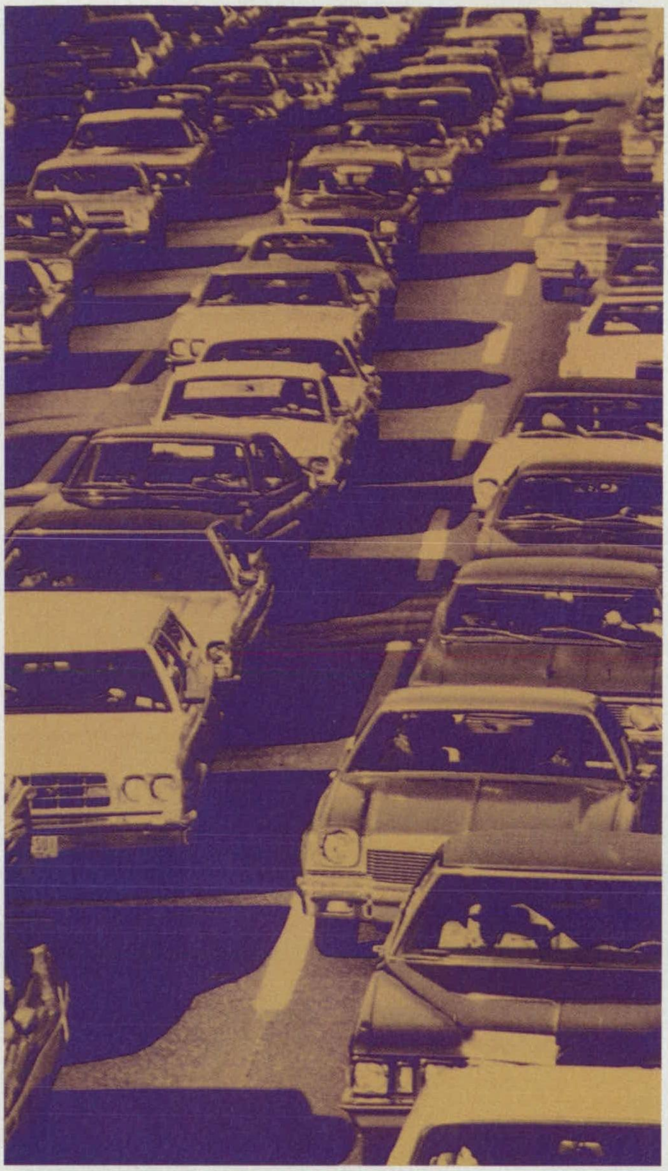
The HELiocentric Observations in X-rays (Gold Helox) telescope will be used aboard the Space Shuttle, which orbits the Earth once every 90 minutes. For about 20 minutes of each orbit, the Sun is in position for long-duration studies. The shuttle will be oriented in such a way that the telescope will be able to collect data for the entire 20 minutes. GoldHelox will take 250 to 300 images of the sun, providing a real-time "movie" of solar activity.

The telescope began as an idea for a paper in technical writing class at BYU.

*For more information, visit the web site at: www.physics.byu.edu/iraf/research/goldhelox/goldhelox.html, or contact Bob Lessels of NASA Marshall at 205-544-6539.*




BYU student Deric Eldridge prepares GoldHelox for the Advanced X-Ray Astrophysics Facility (AXAF) cleanroom facility at NASA Marshall.



# Reader Forum

*Reader Forum is devoted to the thoughts, concerns, questions, and comments of our readers. If you have a comment, a question regarding a specific technical problem, or an answer to a question that appeared in a recent issue, send your letter to the address below.*

*Can someone help me find the results of any studies dealing with the effect of airborne particulate on circuit boards, tape heads, magnetic media, etc.? I also would be interested in whether a clean raised computer room floor results in a lower incidence of ESD risk. Thanks.*

Jay Hagen
j.hagen@mci2000.com

*I am looking for technology that can non-invasively look into the human body. I am aware of the limitations of the CT and new-generation MR scanners. The NASA technology that I originally was interested in was the acoustic microscope, but that is probably not applicable. I'd appreciate any ideas, especially for imaging/detecting bony and soft tissue pathology.*

Srinath Kamineni
skamineni@hotmail.com

*I would appreciate any assistance in locating a small size (AAA battery or less) power source with input pumped by laser or other light source, with output of 5VDC, ~50mW. It must be a kind of light-to-electricity converter that can be used where it is impossible to apply wire to supply the power source. Thank you.*

Igor Troitsky
igor.troitsky@ast.com

*I would appreciate help regarding pointers on how to fund a telemedicine project I have conceived based on a commercial off-the-shelf product we used for developing spacecraft real-time attitude determination. We found it very suitable for potential bio-medical application.*

Sheela Belur
sbelur@csc.com

NASA Tech Briefs *helped me solve a gun erosion modeling problem by directing me to NASA's Lewis Research Center for a thermochemistry code (CET), and to NASA's Marshall Space Flight Center for a nozzle boundary layer code (TDK). Thanks.*

Dr. Samuel Sopok
U.S. Army Benet Labs
Watervliet, NY
ssopok@pica.army.mil

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For More Information Circle No. 572

# NASA PATENTS

*Over the past three decades, NASA has granted more than 1000 patent licenses in virtually every area of technology. The agency has a portfolio of 3000 patents and pending applications available now for license by businesses and individuals, including these recently patented inventions:*

## High-Performance Circularly Polarized Microstrip Antenna

*(U.S. Patent No. 5,661,494)*

Inventor: Probir K. Bondyopadhyay, Johnson Space Center

Microstrip array antennas transmitting or receiving circularly polarized electromagnetic waves in the microwave- and millimeter-wave range are extensively used in communications systems such as mobile-satellite communications, direct-broadcasting-satellite systems, and navigation and radar systems. Described herein is a high-performance microstrip antenna for radiating circularly polarized electromagnetic waves. The antenna consists of an optimally configured cluster array of microstrip radiator elements, each of which is provided with dual orthogonal coplanar feeds in phase-quadrature relation to produce circular polarization. The array is excited in sequential rotation and phasing to enhance the axial ratio of circular polarization over a wide bandwidth. The critical part of the invention is the realization of the optimally configured dual-fed four-element cluster, which results from the reference element together with its microstrip line T-junction power divider being placed with its reference axis at a 45-degree angle with the unit cell reference axis.

## Device and Method for Screening Crystallization Conditions in Solution Crystal Growth

*(U.S. Patent No. 5,641,681)*

Inventor: Daniel C. Carter, Marshall Space Flight Center

An important and rapidly growing field of crystallography is protein crystallography. Proteins are polymers of amino acids and contain thousands of atoms in each molecule. Because of this complexity, obtaining crystals ordered reasonably well so that x-ray crystallography can determine the three-dimensional structure is quite difficult. The present invention provides a new and improved device and method for growing protein crystals and for screening crystallization conditions in solution crystal growth. A housing has at least one pair of chambers for containing crystallization solutions, each of them with an opening to the exterior. The housing includes a fluid communicating orifice connecting each pair of chambers; the orifice receives a detachable tube that contains a predetermined quantity of gelling substance for limiting and/or controlling the rate of diffusive mixing of the crystallization solutions. The device further includes an endcap with a dialysis chamber containing a protein solution secured by a semipermeable membrane. The rate at which the protein solution's solubility is reduced matches the mixing rate of the crystallization solutions, controlling the approach to supersaturation of the protein solution and allowing for quality crystals to be grown.

## Method and Apparatus for the Detection of Hydrogen Using a Metal Alloy

*(U.S. Patent No. 5,668,301)*

Inventor: Gary W. Hunter, Lewis Research Center

Several metals and metal alloys, such as palladium and alloys of palladium containing silver, have applications as hydrogen-sensitive metals. As hydrogen is absorbed by palladium on a substrate, the resistance of the metal changes, and the change can be detected. But these methods have limitations. For instance, as the palladium dissociates and absorbs hydrogen, it undergoes a phase change, causing hysteresis. Furthermore, the phase transformation may damage the layer of palladium. To solve these problems, the present invention is a hydrogen-sensitive metal alloy containing palladium and titanium. The PdTi alloy does not undergo a phase transformation in the presence of hydrogen, and the change in resistance takes place even after repeated exposure to environments containing hydrogen. The titanium also acts as trapping sites for hydrogen, reducing the diffusion of hydrogen through the alloy and yielding a larger change in resistance.

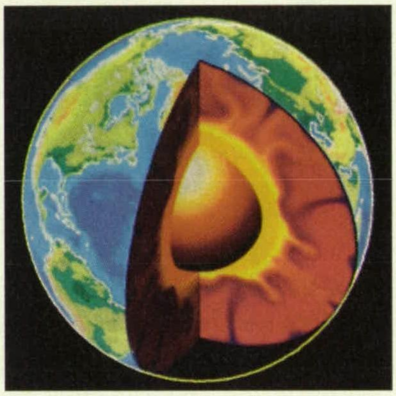
*For more information on the inventions described here, contact the appropriate NASA Field Center's Commercial Technology Office.* *See page 14 for a list of office contacts.*

**This month, in our year-long celebration of NASA's 40th Anniversary, we take a look at successful spinoff products and new applications of NASA technologies in the area of Software.**

# 1970s

## Getting Graphic

Founded in 1977, Research Systems, Inc. (RSI) of Boulder, CO, develops and markets software for analysis and visualization of scientific and engineering data. In 1982, RSI introduced a product called IDL® (Interactive Data Language), developed for use with a broad spectrum of computing hardware.



An IDL 3D rendering shows the magma flow that drives continental plate movements.

IDL's lineage is traced to a software package known as the Mariner Mars spectral Editor (MMED), developed for NASA's Mars flyby spacecraft flown in the late 1960s and early 1970s. The concept embedded in MMED, and the essential element of IDL, was that scientists could test hypotheses without writing a custom program each time data was collected. It provided a general tool that allowed them to investigate the data directly, without programming.

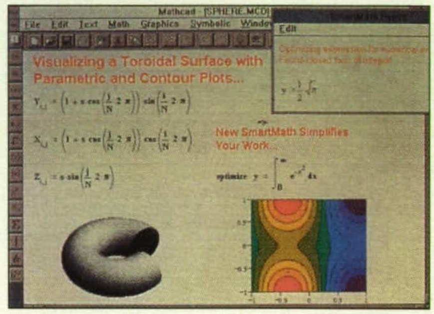
IDL has since progressed through technology generations, and runs on workstations and personal computers. Scientists and engineers in laboratories, universities, and commercial companies use IDL's mathematical analysis and graphical displays for research in physics, remote sensing, astronomy, test and measurement, financial visualization, and medical imaging. NASA, one of RSI's first customers, sponsored development of a Convex version of IDL designed specifically for Goddard Space Flight Center.

# 1980s

## A Calculated Success

In 1985, MathSoft of Cambridge, MA, introduced its first product — Mathcad® calculation software — that provided an easy-to-use alternative to scratchpads, whiteboards, calculators, and spreadsheets. Introduced almost ten years later, Mathcad Plus 5.0 was designed for electrical engineers and computer scientists who needed advanced mathematical functionality. It incorporated an expert system that determined a strategy for solving difficult math problems, then provided the solution. This capability — called SmartMath® — extended the interactive nature of Mathcad.

SmartMath resulted from the integration into Mathcad of CLIPS (C Language Integrated Production System), a NASA-developed shell for creating expert systems. CLIPS allows for the research, development, and delivery of artificial intelligence in conventional computers. Conditions, and the actions to be taken if those conditions are met, are constructed into a rule network by CLIPS' rule engine. As the facts are asserted, they are matched to the rule network.



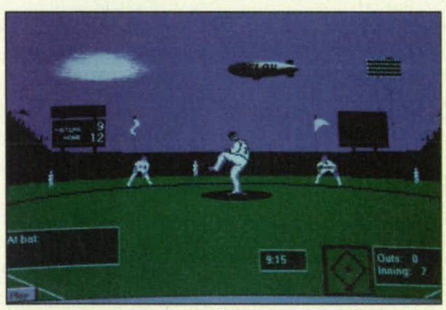

Mathcad enables users to interact with every number and symbol in a range of graphs and plots.

Described as a major advance in calculation software, SmartMath provides an intelligent interface between the user's problem and Mathcad's numeric and symbolic capabilities. By using the NASA-developed CLIPS program, MathSoft saved time and money involved in writing a program from scratch.

MathSoft recently introduced Version 8 of Mathcad, which continues to be one of the leading commercial mathematical/calculation software programs available.

## Let the Games Begin

Psychologist Patrick Doyle worked on a project to train astronauts at NASA's Johnson Space Center in biofeedback techniques in the 1980s. Traditional biofeedback techniques — such as listening to a tone and watching the body respond on a graph — were found to be too mundane, repetitive, and boring. Doyle developed Bio-Games® as a more interesting and involved biofeedback format. The first product, Bio-Ball™, was an interactive, multimedia baseball game played by relaxing in order to hit the ball. The player learns to relax at will, and can generalize the newly acquired skills to real-life situations. Bio-Ball was well-received by NASA, and Doyle moved on to other stress management software. As an associate professor of psychology at the University of Houston/Clear Lake, Doyle created a number of biofeedback games.




Astronaut relaxation techniques using biofeedback have led to stress-relieving commercial software such as Bio-Ball, a baseball game in which deep muscle relaxation controls events.

Creative MultiMedia (CMM) of Houston has marketed a Bio-Games series of interactive video products such as

Bio-Ball©, Bio-Golf©, Clutch City©, 3-D Space Pilot©, and Pachyderm©. Three inexpensive EMG Sensors are connected to the player's forearms or other muscle sites. They monitor tension and communicate the information to the game. The sensors allow the user to play the games without touching their computer keyboards. The software runs on any 486 or better DOS-based computer with Windows.

According to Doyle, "The computer games offer stress management in an enjoyable format so that players can learn to handle live events effectively. As players interact with Bio-Games, there are continuing challenges and new levels of difficulty to keep interest high." Doyle explained that several of the games build team skills by teaming players against the computer.

Doyle's work and the CMM products have been recognized by Steven Spielberg's Starbright Foundation, which focuses on improving the total hospital environments of critically and chronically ill children.

# 1990s

## A Cure for Insecurity

NASA Johnson's CLIPS expert development software tool has been incorporated into other commercial software programs, in addition to Mathcad. Software House of Waltham, MA, manufactures physical security systems for government and business users that include card validation, alarm monitoring, closed-circuit TV, video badging, and biometric identification systems.

The company's primary security management system is called the C•CURESystem 1 Plus™, a software-based family of products that may be used with a variety of access control hardware at installations ranging from individual or remote locations to multiple integrated networks worldwide. Advanced software allows C•CURESystem 1 Plus users to manage large amounts of information and solve particular security problems. They also provide power over access control with time schedules, authorization levels, door entry with card validation, and reporting capabilities.

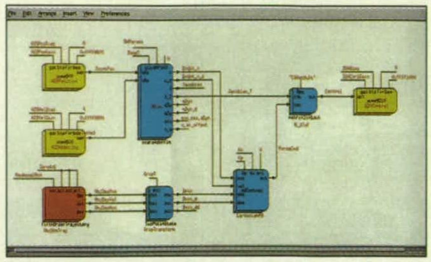
The system also provides access to information management tools such as CLIPS. Using CLIPS, Software House integrated hardware and software to solve problems associated with access control systems. The expert system software prototype asks questions about what the hardware is doing; from the answers given, the program recommends possible routes to check and what could be causing the problem.

CLIPS enabled Software House to develop new generations of hardware that allow problem-solving by a non-expert.

## Under Control

In 1996, Real-Time Innovations (RTI) of Sunnyvale, CA, became the first "graduate" of NASA Ames Research Center's Technology Commercialization Center. RTI had collaborated with Ames, NASA's Jet Propulsion Laboratory, and Stanford University to leverage NASA research to produce ControlShell™ real-time command and control software. The software is capable of processing information and controlling mechanical devices, allowing large groups of programmers and projects to share and reuse software objects. The system was used on a cooperative project to enhance the capabilities of a Russian-built Marsokhod rover. NASA avionics and a ControlShell controller were used in the upgrade.

ControlShell enables users to build applications from small code objects called components, which let developers share and reuse code. Other features include the ability to graphically automate sophisticated feedback-loop control, and event-driven reactive logical programming. Novice programmers easily can build structured, quality code.



ControlShell, spun off of NASA Ames software to run space robots, found earthly applications such as hazardous waste site inspection.

One of the ControlShell tools is RTI's StethoScope®, a real-time data collection and display tool that allows a user to see how a program is running without changing its execution. A live, graphical window enables the user to change values, monitor variables, archive data, and collect time histories without affecting how a system is executing.

ControlShell has been used in telecommunications, networking, video editing, semiconductor manufacturing, automotive systems, and medical imaging.

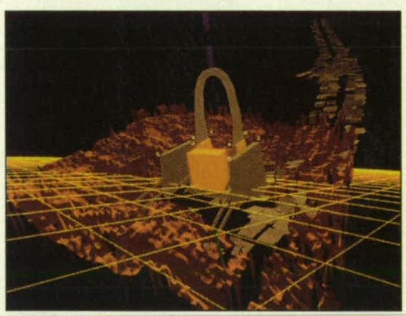
## Visual Computing

Founded in 1996, Fourth Planet of Santa Clara, CA, is a visualization company that specializes in the intuitive visual representation of dynamic, real-time data over the Internet and Intranets. The company has as its core a team formerly with Ames Research Center's Intelligent Mechanisms Group (IMG).

Over a five-year period with NASA, the group performed ten robotic field missions in harsh environments, including underwater in Antarctica, the Kilauea volcano, and Alaska's Mount Spurr. Each test was designed to duplicate the end-to-end operations of automated vehicles traveling across another world under control from Earth. The core software used for the missions was the Virtual Environment Vehicle Interface (VEVI), developed at Ames.

First runner-up in NASA's 1996 Software of the Year competition, VEVI is a modular operator interface for direct teleoperation and supervisory control of robotic vehicles. It uses real-time interactive 3D graphics and position/orientation sensors to produce vehicle control capabilities. It has been used to control wheeled, legged, air-bearing, and underwater vehicles.

Fourth Planet was started by Butler Hine, director of the IMG at Ames, and five other partners. Their mission was to bring together three important technologies: real-time data, networking computing, and 3D graphics and data visualization to revolutionize the world of computing.



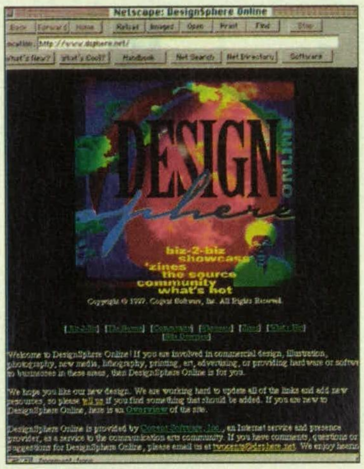
Based on NASA software, VEVI14 represents complex devices graphically in a 3D environment. Shown here is the Dante II vehicle during its descent into Mount Spurr, Alaska.

VEVI14 is the fourth generation of the VEVI Ames software. The commercially available tool can represent complex devices graphically in a 3D environment. NetVision, another Fourth Planet product, allows large companies to graphically view and analyze in virtual 3D space things such as the health and performance of their computer network, locate trouble spots on electric power grids, or evaluate a web of computer links.

## The Information Revolution

David Atkinson, president and CEO of Cogent Software, Pasadena, CA, believes that the Internet is changing the way we do business. He founded the company in 1995 to support customers with Internet business solutions, and now serves small offices and large manufacturers.

Atkinson and his partner, Irene Woerner, along with other Cogent employees, formerly worked at NASA's Jet Propulsion Laboratory, where Atkinson was the head of JPL's Information Systems Technology Section. There, he manage operations technology and artificial intelligence program development for NASA. Woerner led JPL's Advanced User Interfaces Group, where she developed and directed research and development of NASA hypermedia library systems.



Created with expertise obtained at NASA, Cogent Software's services and products, such as DesignSphere Online, support customers with Internet business solutions.

Cogent helps companies organize and manage online content by developing advanced software for the next generation of online directories and catalogs. The company offers a range of Internet solutions, including Internet access, Web site design, local- and wide-area network solutions, and custom software. As a service, Cogent provides DesignSphere Online, which aims to build an electronic community for the communications arts industry.

## A Good Case

Case-based reasoning (CBR) is a problem-solving paradigm that adapts stored problem solutions, or cases, to solve new problems specified by the user. It is applicable to a variety of construction and classification tasks, and is particularly useful where a formal set of rules for generating a solution is hard to obtain, but examples of correct solutions to similar problems are available.

A standalone commercial software product based on CBR, called CBR Express™, was introduced in the early 1990s by Inference Corp. of El Segundo, CA. The program incorporates technology originally developed by Inference through work on the Advanced Software Development Workstation (ASDW) for NASA's Johnson Space Center (JSC). The JSC project focused on reusing software designs and components to reduce costs and relieve a bottleneck in software development and maintenance of deployed systems. Reuse of software involves retrieving and modifying existing software components using a method that was a knowledge-based system. The system provided a software parts composition system, which consists of a language for modeling software parts and their interfaces; a catalog of existing parts; an editor for combining parts; and a code generator that takes a specification and generates code for that application in the target language.

In NASA's ASDW project, Inference employed CBR in the reuse process as part of the ACCESS prototype software, a knowledge-based software information system designed to assist the user in modifying or configuring retrieved software or design objects to the user's specifications.

The resulting CBR Express is used as a help desk for customer support, enabling reuse of existing information when necessary. It has been adopted by companies such as American Airlines, GTE Corp., and Nippon Steel.

## Space Age Training

Teledyne Brown Engineering (TBE) of Huntsville, AL, introduced to the commercial market a training aid designed to help companies train their workforces. The computer-based system for industrial process training is called the Interactive Multimedia Training (IMT) system, an offshoot of a system developed by TBE under management by NASA's Marshall Space Flight Center. The system was developed to train astronauts and space operations personnel in the on-orbit operation of scientific experiments.

The TBE contract with Marshall involved training the crew of Space Shuttle flight STS-73, which launched on October 20, 1995. The crew used a Teledyne Brown high-temperature furnace for growing electro-optical and protein crystals. In addition to the crew, the ground-based space operations technicians and investigators of crystal growth processes had to be trained in the operation of the furnace's hardware and software, as well as operational procedures involved in crystal growth research.

The IMT system was chosen to train the team by presenting information in a way that engages all the senses — it uses text, video, voice, animation, sounds, and music. Learners can direct the learning process at their own pace, allowing them to repeat portions as many times as necessary. Advanced simulations place learners in role-playing scenarios where they must react or interact as if on the job.

TBE cites advantages of the multimedia training concept as simple explanation of difficult concepts; increased trainee comprehension; shorter learning time; standardized course quality and content, not dependent on the skills and knowledge of the instructor; and reduced or eliminated travel time and expense to send crews for training.

Since 1976, *NASA Spinoff* has featured many down-to-earth applications of NASA technology. To learn more about how NASA technologies affect our everyday lives, visit the *Spinoff* web site at: www.sti.nasa.gov/tto/spinoff.html

**To Contact Profiled Companies, Call:**

| | |
|---|---|
| Cogent Software | 818-585-2788 |
| Creative MultiMedia | 281-461-0276 |
| Fourth Planet | 415-949-2742 |
| Inference Corp. | 213-322-0200 |
| MathSoft | 617-577-1017 |
| Real-Time Innovations | 408-720-8312 |
| Research Systems | 303-786-9900 |
| Software House | 617-466-6660 |
| Teledyne Brown Engineering | 205-726-5544 |

**Next Month:**

**NASA Technologies for Medical and Health Applications**

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**For More Information Circle No. 544**

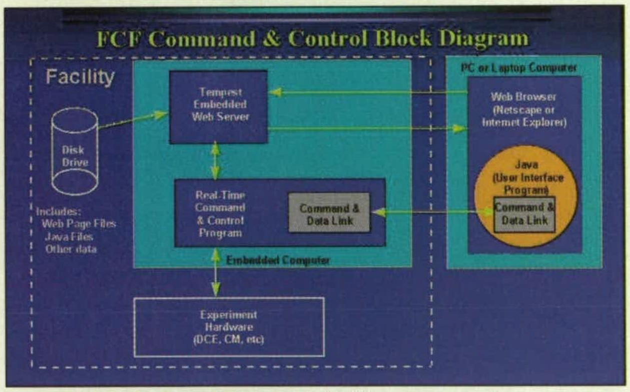
# NASA's 1998 Software of the Year

A computer program designed to remotely control International Space Station experiments through the Internet, and software to improve air traffic control have been named winners of this year's NASA Software of the Year Award. Selected by NASA's Inventions and Contributions Board, the award is presented to NASA-developed software that has significantly enhanced NASA's performance of its mission, while helping American industry. The awards will be presented at a reception during Tech East '98, November 3-5, at Boston's Hynes Convention Center.

*Information on the NASA Software of the Year Awards can be found at http://www.hq.nasa.gov/office/codei/swy98win.html*

## Tempest

Originally developed to support the science experiments on the International Space Station, Tempest is fully documented, installs simply, and uses standard World Wide Web browsers to let users operate experiments. It is an embedded Web real-time HTTP server that accepts requests from standard browsers running on remote clients, and returns HTML files. It serves Java applets, CORBA, virtual reality (VRML), audio, and video files. There are two versions of




**Tempest accepts requests from standard browsers running on remote clients and returns HTML files.**

Tempest: VxWorks, with a 34 kB footprint; and Java, with 4- to 6-millisecond transaction speeds.

The program enables software project teams working on real-time command and control systems to leverage the work of thousands of software designers in the Internet/World Wide Web arena, reducing software lifecycle time and producing high-quality, up-to-date applications.

Tempest is considered to be breakthrough and enabling technology, and has an estimated extensive market in Web-embedded remote control mechanisms, especially in the automotive, consumer electronics, office products, and medical industries. According to NASA, the embedded processor market is expected to be larger than the desktop market, and should grow to more than $100 billion in the next decade. Tempest-like products are expected to be applicable to most, if not all, of those applications.

Tempest was written by Maria Babula, Lisa Lambert, Joseph Ponyik, and David York of NASA's Lewis Research Center in Cleveland, OH; and Richard A. Tyo of Intel Corp.

*For commercial information on Tempest, contact Priscilla Diem of the Great Lakes Industrial Technology Center at 440-734-1186; for technical information, contact David York of NASA Lewis at 216-433-3162.*

## CTAS Software

Center TRACON Automation System (CTAS) Software is a set of three software tools for managing air traffic control systems at major airports. The three components are Traffic Management Advisor (TMA), Final Approach Spacing Tool (FAST), and Conflict Predictor Trial Planner (CPTP). The system is designed to optimize flight operations, saving an average of two minutes per flight, and saving money for airlines and passengers.

CTAS is in daily use at the Dallas/Ft. Worth International

**In daily use at the Dallas/Ft. Worth International airport, CTAS software has been seamlessly integrated into the existing radar system, with its own displays supplementing the manual air traffic control system.**

Airport, where it has been seamlessly integrated into the existing radar system, with displays in the control room supplementing the manual air traffic control system. The software analyzes and predicts aircraft paths, creating visual representations of the flow of arriving traffic. It provides controllers with up-to-the-second advisories of information to pass on to pilots that will reduce the time between landings to a minimum.

CTAS assists controllers handling arrival air traffic in an area within 40 miles of a major airport. Within these areas, known as Terminal Radar Approach Controls (TRACONs), CTAS also assists approach controllers to assign aircraft to runways as well as sequence and schedule aircraft onto the final approach to the runway. It makes use of highly sophisticated performance models of the major aircraft types encountered at Centers and TRACONs, including jets, turboprops, and piston engine aircraft. Each element of CTAS adapts to changes in the traffic situation, and pilot and airline preferences.

The Federal Aviation Administration (FAA) has chosen Center TRACON for immediate implementation into all major airports, and estimates that its use could save airports as much as $800 million each year.

The Center TRACON Automation System Software was written by Michelle Eshow and a team of 37 others at NASA's Ames Research Center in Moffett Field, CA.

*For more information on CTAS software, contact NASA Ames Public Affairs Office at 650-604-4968.*

# Commercialization Opportunities

### Active-Pixel Sensors With "Winner-Take-All" Mode

Circuits that generate the intensity reading and the coordinates of the brightest pixel in each image will be added to imaging photodetector arrays of the active-pixel sensor type. Potential applications are star tracking or fast tracking of a moving laser-beam spot in laser communication systems.
(See page 43.)

### Optimized Two-Wavelength Focal-Plane Arrays of QWIPs

A concept for optimizing the designs of two-wavelength GaAs-based QWIPs could make it practical to use focal-plane arrays of QWIPs as image sensors in two-wavelength infrared cameras. Potential applications for such cameras are surveillance, tracking of military targets, night vision, and thermal mapping.
(See page 48.)

### Micromachined Magnetostatic Switches

These switches are being developed and fabricated with micromachining techniques. The switches operate similarly to magnetic reed switches but are much smaller. Potential applications are in electronic commutation circuitry in brushless dc motors. Also, an array could serve as a rotary encoder or magnetometer.
(See page 58.)

### Improved Process for Scrubbing and Treating $NO_x$ Liquor

A new process and equipment reduce emissions of hazardous nitrogen oxides from spacecraft-propellant operations. The process converts $NO_x$ into an aqueous solution of potassium nitrate, which can be used as a fertilizer.
(See page 68.)

### Robot Hands With Electroactive-Polymer Fingers

Simple, compact, and lightweight robotic end effectors have been developed with fingers that bend and function similarly to human fingers. The fingers are made of electroactive polymers that are much lighter and have about 100 times more actuation strain than electroactive ceramics and can be mass produced at relatively low cost.
(See page 78.)

### Microfabricated Ice Sensors

Prototypes of compact, low-power transducers have been developed to detect the presence of ice on critical surfaces of aircraft. Other possible applications are detecting ice in refrigerators to trigger defrosting cycles and detecting ice on roadways to trigger warnings to drivers.
(See page 83.)

## Power Monitoring System Protects JPL

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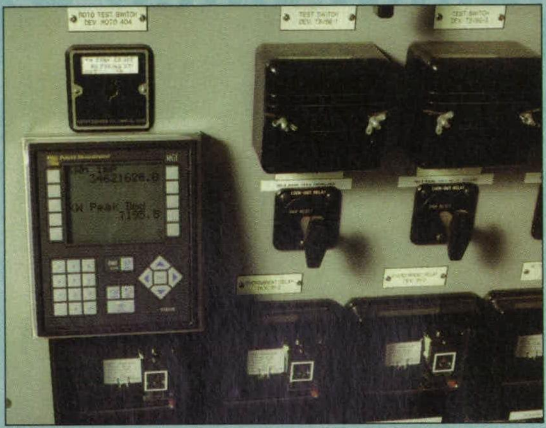
Power disturbances at NASA's Jet Propulsion Laboratory (JPL) can have severe consequences, such as instrument damage, computer crashes, lost research data, assembly disruptions due to equipment failure, and reduced motor efficiency and life spans. The most common disturbances are momentary voltage sags and transients, and longer-duration brownouts, usually caused by the utility's load switching, capacitor switching, or fallen power lines. Thus, a power monitoring system that can identify potential problems was essential.

Vaji Nasoordeen, JPL's Energy Manager and Manager of Maintenance and Operations, explained that, "Most of JPL's 144 buildings contain very sensitive devices that require the best power quality in order to run reliably." To protect equipment, JPL's Electrical Services Group installed power conditioners, but they also wanted to develop a more proactive scheme that addressed the roots of the problems. For this, they needed a continuously operating, company-wide power monitoring system that could capture unexpected disturbances, record waveforms, log historical data, track load profiles, and make the information available at the desktop through their existing computer network.



**One of several panel-mounted 7700 IONs monitors energy and power quality at a key point in JPL's electrical distribution network.**

The group selected a system from Power Measurement that consisted of 7700 ION and 7300 ION digital power meters, and PEGASYS software, all communicating over Ethernet. The system monitors the power that is distributed to JPL's buildings. Five workstations display graphical, real-time power and energy information.

A bonus for JPL has been the ability to monitor energy consumption and control demand. "PEGASYS provides insight into energy usage across JPL's campus," said Nasoordeen. "It's also a good tool for forecasting load patterns, which helps us optimize power distribution to various labs." Reports can be generated to reveal other trends and opportunities for energy conservation.

**For More Information Circle No. 755**

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## A Sound Solution for NASA Test Chamber

**Sonex foam acoustic wedges**
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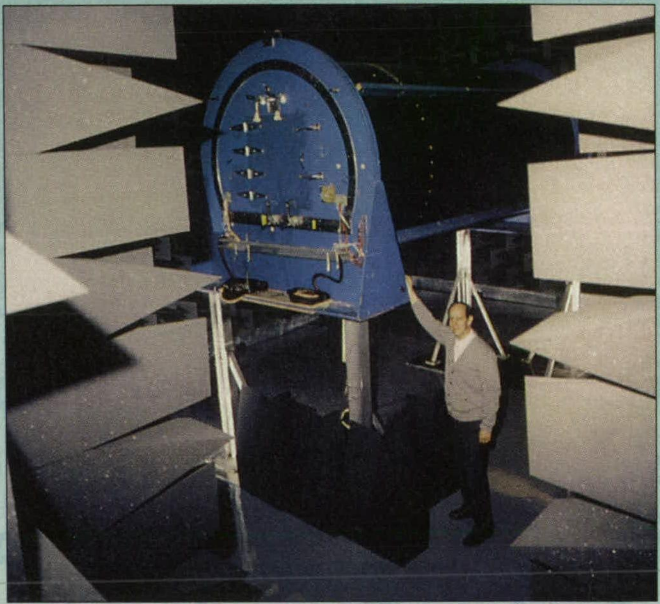
**Fax: 612-521-5639**
**www.illbruck-sonex.com**

A large semi-anechoic chamber for acoustic testing of full-size and model aircraft structures at NASA's Langley Research Center required a series of one dozen 16 x 16' moveable partitions covered with acoustic foam wedges. The goal was to surround an aircraft structure with sound transmission barrier walls that would create a nonreverberating test environment, and attenuate noise coming from the test area by at least 25 decibels at all 1/3 octave bands above 500 Hz.

The original NASA design called for the individual partitions to be constructed from a material with a sufficient mass per unit area density to block sound, but light enough to be moved by an overhead crane with a five-ton limit. The partitions would enclose an area 28 x 50', and be covered with 36 x 12 x 12" blocks of fire-retardant polyurethane foam, tapered to 24"-long wedges.

illbruck and Energy Services Group International of Williamsburg, VA, proposed constructing the partitions of lower-cost 16-gauge galvanized steel, which met the acoustic performance NASA required. Energy Services Group constructed the 12 partitions, and illbruck supplied the 4,946 foam acoustic wedges for the partitions and the floor. In four weeks, the chamber was complete.



**Project director Dr. Ferdinand Grosveld, in the semi-anechoic test chamber.**

**For More Information Circle No. 756**

October 1998

# PHOTONICS Tech Briefs

## Sloan Digital Sky Survey

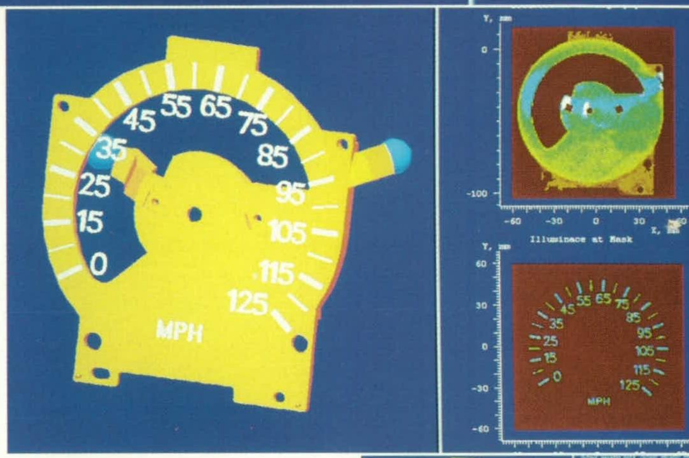
Photonics East/Electronic Imaging Int'l Exhibit Preview

New Photonics Products—
see page 27a

bulk absorption • data import/export • energy distribution • unlimited receivers • catalog and user materials

# *Imagine Illumination Software That's Easy to Learn, Powerful to Design With, and Fun to Use.*


# *Imagine LightTools®*

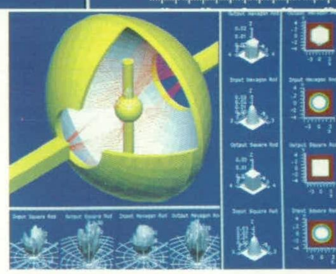



### Imagine Easily Mastering New Software.

Our new Illumination Module is built on the award winning, 3D interactive solids modeling program, *LightTools*. It's so easy to learn, so intuitive and easy to use because our graphical interface allows you to rapidly model your entire illumination system, including sources, optics, mechanical parts, and receivers. All of this without needing to manipulate complex macros or rely on importing models from separate CAD programs. Which means you can say good-bye to long learning curves.

### Imagine Testing a Mock Up Without Building a Mock Up.

Imagine illumination software that allows you to: define multiple illumination sources and receivers, specify surface optical properties, specify the type of illumination analysis desired and select the type of graphical output you want. *LightTools* gives optical and mechanical engineers the ability to quickly explore, visualize and analyze the functional trade-offs of alternative illumination designs. All without the need to build expensive prototypes. Which means you can say good-bye to trial and error design.



### Imagine Trying *LightTools* Software for FREE.

And now for a limited time, we invite you to try *LightTools* Illumination module for 30 days. Free. Once you've tried *LightTools*, we're confident you won't imagine working without it. All of which means you 'll be spending more time stretching your imagination and less time mastering the software.

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**For More Information Circle No. 487**

# PHOTONICS Tech Briefs

Supplement to *NASA Tech Briefs'* October 1998 Issue Published by Associated Business Publications



**On the cover:** The 2.5-meter reflecting telescope of the Sloan Digital Sky Survey project at the Apache Point Observatory in the Sacramento Mountains of New Mexico. Photo courtesy of Fermilab Visual Media Services.

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# Mapping the Night Sky

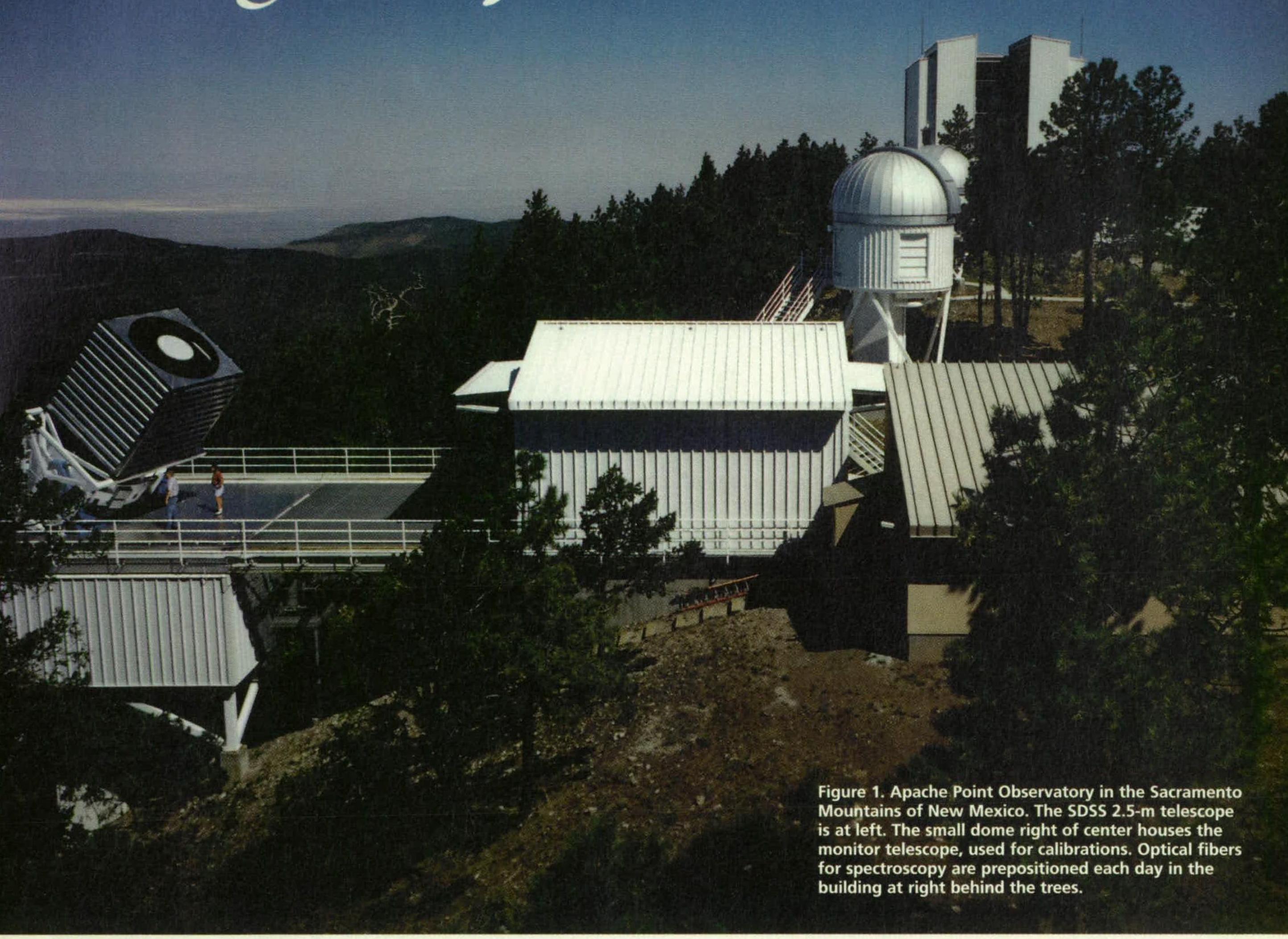

Figure 1. Apache Point Observatory in the Sacramento Mountains of New Mexico. The SDSS 2.5-m telescope is at left. The small dome right of center houses the monitor telescope, used for calibrations. Optical fibers for spectroscopy are prepositioned each day in the building at right behind the trees.

A major five-year astronomical undertaking called the Sloan Digital Sky Survey (SDSS) will seek to unlock the secrets of the night sky. The SDSS will result in the first five-color charge-coupled-device (CCD) photometric "map" of the North Galactic hemisphere, totaling 10,000 square degrees of coverage. Scientists expect the SDSS to locate some 500 million galaxies and an even greater number of stars, while gathering the spectra of 1 million galaxies and 100,000 quasars. In total, the survey will collect an estimated 10 terabytes of data. Researchers will gain an unprecedented look into the three-dimensional large-scale structure of galaxies (to a median red shift of $z=0.1$), the evolution, surface density, and morphology of galaxies, and the evolution and large-scale distribution of quasars. Various institutions are jointly sponsoring the SDSS, among them Princeton University, the University of Chicago, Johns Hopkins University, the U.S. Naval Observatory, Fermi National Accelerator Laboratory, the University of Washington, the Institute for Advanced Study, the National Astronomical Observatory of Japan, and the University of Tokyo.

The Sloan Digital Sky Survey, with SITe CCDs at its heart, will supply a quantity and quality of data about the universe never before available.

Based at New Mexico's Apache Point Observatory (Figure 1), the SDSS employs a dedicated 2.5-meter f/5 telescope built to a distortion-free Ritchey-Chretien optical design. This telescope, with a 3-degree field of view (FOV), achieved first light on May 9 of this year.

At the instrument's heart is a large-format CCD camera mosaicked on the telescope's focal plane. Operating in the time-delay-and-integrate (TDI) scanning mode and 10,000 times more sensitive to light than a consumer digital camera, the SDSS camera is made up of two arrays. A photometric array, consisting of 30 2048-x-2048-pixel CCDs produced by Scientific Imaging Technologies Inc. (SITe), offers an effective imaging area of 72 cm$^2$. These SITe Model SI424A CCDs (Figure 2), with 24-µm pixels, are

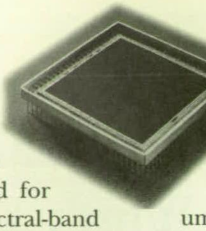

Figure 2. SDSS telescope photometric CCD from SITe.

arranged in six columns of five chips each (Figure 3) so that two scans cover a filled stripe 2.54 degrees wide. Twenty-four of these CCDs are back-illuminated for improved UV and blue spectral-band sensitivity, and the remaining six are front-illuminated. The second array, an astrometric array, consists of 24 front-illuminated 2048-x-400-pixel custom-built SITe CCDs with 24-µm pixels, allowing SDSS researchers to couple bright astrometric standard stars to celestial objects imaged via the photometric array.

## An Ideal Match

The sheer size of the SI424A CCDs, approximately 4 square inches each, makes them an ideal match for a telescope that captures a relatively large 3-degree FOV. For enhanced sensitivity, each column of five CCDs is encased in a liquid nitrogen-cooled vacuum-sealed chamber. The six CCDs in each row are fitted with one of five color filters centered at the following wavelengths: 350 nm (blue), 477 nm (green), 623 nm (red), 762 nm (near-IR), and 913 nm (IR).

Center-to-center spacing between photometric array columns is 91 mm, slightly less than twice the active width of the CCDs, which allows two scans to cover the 2.54°-wide filled stripe (with an 8-percent overlap between scans along each edge). Scanning is at sidereal rate. A star or another celestial body's image crosses the entire photometric array in 5 minutes and 42 seconds, traversing it in the column direction. Effective exposure time is 54.1 seconds for each of the five colors along a column, and spacing in time from one color to the next is 72 seconds.

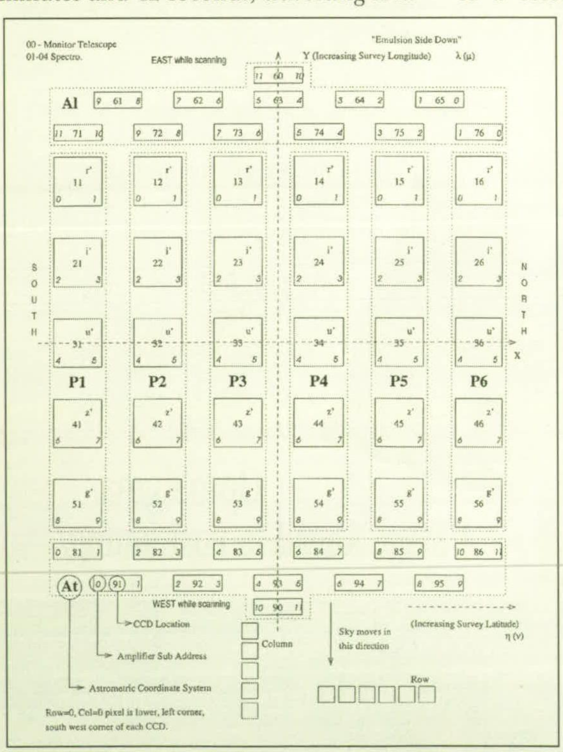


Figure 3. SDSS telescope/CCD camera array: 30 photometric CCDs (11-56) and 24 astrometric CCDs (60-76, 81-95).

The astrometric array's CCDs are situated in the focal-plane space above and below the photometric array. Twelve CCDs make up the leading astrometric array, above the photometric, and the remaining 12 make up the trailing astrometric array below it. Each astrometric array is arranged in two rows, with one row of six CCDs aligned with the photometric columns, a second row of five CCDs straddling the columns, and the final CCD adjacent to the middle CCD in the row of five. The astrometric CCDs utilize passband filters centered at 623 nm plus ND 3 neutral density filters.

Over the Sloan Digital Sky Survey's five-year lifespan, scientists will spend some 200 nights observing the heavens through the telescope. Spectral analysis of celestial bodies first involves selecting a group of 640 objects for study. Then the same number of holes are drilled in an aluminum plug plate (Figure 4), with each hole corresponding to the location of a selected star, quasar, or galaxy. These holes are fitted with fiber-optic cables that connect to a high-multiplex-gain, multiobject spectrograph, enabling simultaneous capture of the 640 objects' spectra. The plug plates, interchangeable with the SDSS camera, are placed at the Cassegrain focus position. On a good night for observation, six to nine plug plates are used.

## New Levels of Data

Upon completion, the SDSS will provide a depth of data not available in the sky survey tool now considered the standard: the National Geographic Society-Palomar Observatory Sky Survey. Undertaken between the late 1940s and early 1950s, the Palomar survey utilized more than 900 pairs of 14-inch-square photographic glass plates to record the sky visible from the Northern Hemisphere. The two-color survey centered on the spectrum's visible portion, recording one band in blue and the other in red.

While the Palomar survey has served scientists well, it does have significant limitations. Since it is photographic, visually counting and analyzing large numbers of closely clustered stars, galaxies, and other celestial objects in the silver halide emulsion is extremely difficult. In addition, as a two-dimensional study the Palomar survey reveals the positions of celestial objects but does not indicate their distances along the line of sight.

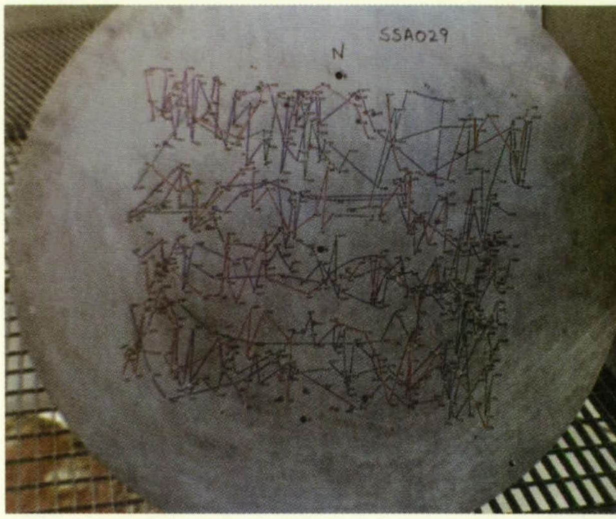


Figure 4. An aluminum plug plate, showing positions and identification of holes for fiber optic lines that will collect information about galaxies, stars, and quasars.

As a digital study, however, the Sloan survey is able to concretely distinguish one celestial object from another, no matter how cluttered the sky. The SDSS also is able to detect objects 10 to 20 times fainter than the dimmest objects recorded via the Palomar survey. And when it is complete, the SDSS will provide three-dimensional coordinates for numerous galaxies and quasars.

SDSS project scientist Jim Gunn of Princeton University says the Sloan Digital Sky Survey will pointedly demonstrate nature's extreme complexity. Though one cannot predict everything that will come out of the SDSS, the survey should provide solid information about the way matter is distributed in the universe. This data, Gunn explains, should help answer many questions concerning the universe's large-scale structure and its connection with fundamental physics.

*For more information on Scientific Imaging Technologies' products and applications, contact George Williams, SITe, 14320 S.W. Jenkins Road, Beaverton, OR 97007; (503) 671-0688; fax (503) 671-7110; www.site-inc.com. For more information on the Sloan Digital Sky Survey, see www.sdss.org.*

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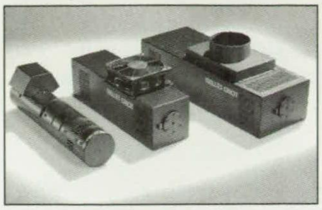

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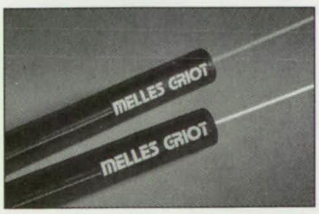


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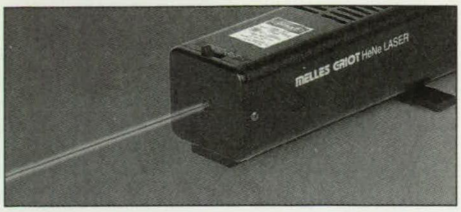


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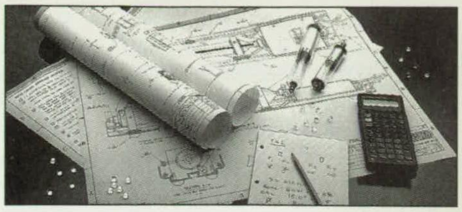

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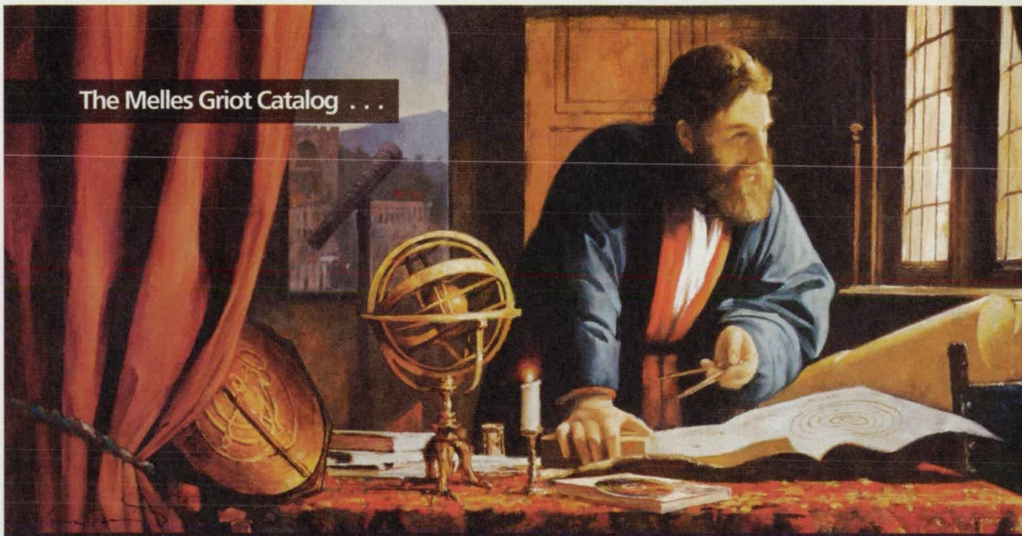


**Galileo Galilei** (1564-1642), Italian mathematician and astronomer, discovered the satellites of Jupiter using a two lens telescope.

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# PHOTONICS EAST/ELECTRONIC IMAGING INT'L EXHIBITS PREVIEW

Photonics East and Electronic Imaging International are two of an alliance of six synergistic events coming together as Tech East '98 November 1-5, 1998, at the Hynes Convention Center, Boston, MA. The event will offer more than 100,000 square feet of free exhibits demonstrating new inventions and products from leading OEMs, universities, and federal laboratories. SPIE—the International Society for Optical Engineering sponsors both Photonics East and Electronic Imaging International, joined by cosponsor *Photonics Tech Briefs* magazine in the former. Below is information on this year's exhibitors (as of August 15).

Photonics EAST

## PHOTONICS EAST EXHIBITORS

**Ablestik Electronic Materials & Adhesives 1131**
Rancho Domiguez, CA
Ablestik Luxtrak™ adhesives provide flexible, resilient, or rigid bonds.

**Acton Research Corp. 930**
Acton, MA
Excimer/UV laser optics, VUV-NIR optical filters, and the new 20-bit NCL spectral acquisition system for spectroscopy.

**Advanced Manufacturing International 1209, 1211**
Sparks, MD
The premier global contract manufacturer for high-precision mechanical and electro-mechanical components and assemblies.

**Alcoa Fujikura, Ltd. 739**
Spartanburg, SC
Full service connectorization for all types of lasers, diodes, transmitters, and receivers.

**American Holographic, Inc. 914**
Fitchburg, MA
The world's largest and foremost supplier of standard and custom original holographic gratings.

**American Institute of Physics 838**
Woodbury, NY
Publisher of *Medical Physics*, the monthly scientific journal of the American Association of Physicists in Medicine.

**American Laser Corp. 1125**
Salt Lake City, UT

**Anritsu Company 1110**
Richardson, TX
A leading manufacturer of fiber optic test equipment, laser and superluminescent diodes.

**APOMA-American Precision Optics Manufacturers Association 729**
Rochester, NY

**Applied Image, Inc. 920**
Rochester, NY
Manufacturer of custom and off-the-shelf opto-imaging components, standards, test targets, encoders, cylinders, mirrors, flats, and more.

**Argyle International Inc. 840, 842**
Princeton, NJ
Supplies lenses, prisms, mirrors, filters, windows, custom designs, molded and machined parts.

**Barr Associates, Inc. 817**
Westford, MA
New astronomical filter set includes over 60 of the most popular among the astronomers community.

**BitFlow, Inc. 224, 226**
Woburn, MA

**Blue Sky Research 750**
San Jose, CA
CircuLaser™ diodes with circular, fully-corrected beams; FiberBrite™ high-power single-mode fiber-pigtailed laser systems; Laser Wave Analyzer™ analysis systems; and more.

**Boston Electronics Corp. 1015, 1017**
Brookline, MA
UV and IR detectors, IR sources, lidar electronics, choppers and lock-in amplifiers, shutters, evaporation-grade Ge for IR thin films, and more.

**Business Communications Co. 733**
Norwalk, CT
Publisher of technical/economic reports and newsletters, some of which deal with NDE-related topics.

**Cambridge Technology, Inc. 837, 839**
Cambridge, MA
The technology leader in galvanometer-based optical scanning components, providing the fastest and most accurate laser beam steering.

**Canadian Instrumentation & Research Ltd. 752**
Burlington, Ontario, Canada
Manufactures polarization-preserving fiber optic devices: evanescent wave couplers, polarization splitters, piezo modulators, and more.

**Centronic, Ltd. 1015, 1017**
Croydon Surrey, UK
Manufacturer of DIAMOND UV photodetectors for 180 to 230 nm.

**Coherent Auburn Group 742, 744**
Auburn, CA
The Coherent Catalog (available on CD-ROM) is a one-stop source for optical and optomechanical components, lasers, and light sources.

**Cosmo Optics, Inc. 1216**
Middletown, NY
Specializes in prototypes and small production runs, including fabrication of optical components, mechanical parts and assemblies.

**Crosslight Software Inc. 834**
Gloucester, Ontario, Canada
Specializies in the creation of award-winning device simulation software to model semiconductor lasers.

**CVI Laser Corp. 1104**
Albuquerque, NM
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**Digital Optics Corp. 1021**
Charlotte, NC
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**Dynasil Corp. 1036**
West Berlin, NJ

**Edmund Scientific Co. 924, 926**
**Industrial Optics Division**
Barrington, NJ
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**EG&G Optoelectronics 913**
Salem, MA
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**Electro-Optical Systems, Inc. 1115**
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**Electron Tubes, Inc. 1213**
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**Engis Corp. 735**
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**Environmental Technologies Group, Inc. (ETG) 1231**
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**Epner Technology, Inc.** 741
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**General Scanning, Inc.** 1105
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**JML Optical Industries Inc.** 934
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**Lambda Physik, Inc.** 1127
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**Laser Drive, Inc.** 828
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**Laser Focus World** 825, 827
**PennWell Publishing Co.**
Nashua, NH
A monthly magazine for engineers, researchers, scientists, and technical managers, providing comprehensive global coverage of electro-optic technologies and markets.

**Lasers & Optronics** 1124
Morris Plains, NJ
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**LEXITEK Inc.** 757
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**Licel GbR** 1015, 1017
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**Lightwave Magazine** 1224
**PennWell Publishing Co.**
Nashua, NH
A monthly international publication focusing on fiber optics and optoelectronics for telephony, computer communications, and video.

**LIMO GmbH** 927
Dortmund, Germany
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**Lincoln Laser Co.** 1020, 1022
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**Litton Electro-Optical Systems** 1225
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**Logitech Product Group** 824
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**Mildex, Inc. 1122**
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**Olympus America, Inc. 1111**
**Precision Instrument Division**
Melville, NY
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**OPCO Lab., Inc. 1023**
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**OPTICS 1, Inc. 922**
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**Philips Components** **905**
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**Photonetics Inc.** **1139**
Peabody, MA

**Photonics Spectra** **1114, 1116**
Pittsfield, MA
A leading photonics monthly magazine. The *Photonics Directory* is a 4-book set that includes the Corporate Guide, Buyers' Guide, Handbook, and Dictionary.

**Photonics Tech Briefs** **1212**
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*Photonics Tech Briefs* is a FREE bimonthly publication distributed to more than 85,000 NASA Tech Briefs readers who recommend, specify, or authorize purchase of lasers, optics, video, and imaging products.

**Physical Optics Corp.** **1121, 1123**
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**Phytron, Inc.** **833**
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**Raytheon Systems Co.** **1014**
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ExplorIR is a high-performance imaging radiometer designed for condition-monitoring professionals. ExplorIR features a 320-(-240-element uncooled microbolometer FPA.

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**Rocky Mountain Instrument Co.** **912**
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From UV to FAR-IR, prototype to production, RMI is a leading manufacturer of laser optics, coatings and electro-optic products.

**SPIE-The International Society For Optical Engineering**
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An international technical society dedicated to advancing engineering, scientific, and commercial applications of optical technologies.

**SSI-Scientific Solutions Inc.** **826**
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Specialized fused, flexible and rigid fiber optic imaging components: High-resolution and high-expansion faceplates for CRTs, image conduits, tapers, and flexible image bundles.

**Schott Glass Technologies, Inc.** **1009, 1011, 1013**
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**SCI-TEC Instruments Inc.** **936**
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**Scitec Instruments Ltd.** **1015, 1017**
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**Speedring Systems, Inc.** **1222**
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**Spindler & Hoyer, Inc.** **1024**
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**Spiricon, Inc.** **916**
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**Stanford Research Systems, Inc.** **1026**
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**STARMET Corp.** **1226**
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**Strasbaugh** **818**
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**Sumita Optical Glass, Inc.** **1221, 1223**
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**Symtx** **1108**
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**TASK Micro-Electronics Inc. 1126**
Dollard-Des-Orme, Quebec, Canada
Solutions to electronic circuit and electro-optic packaging needs, using advanced hybrid, flip-chip, chip-and-wire, chip-on-chip, flex, and SMT assemblies.

**UDT Sensors, Inc. 1005, 1007**
Hawthorne, CA
Designer and manufacturer of high-performance silicon photodiodes, position sensors, avalanche detectors, linear arrays, detector/amplifier hybrids, detector/filter assemblies, and more.



**United Lens Company, Inc. 915, 917**
Southbridge, MA
Manufacturer of molded and machined lens blanks, precision flat optics, and thin-film coatings.

**Universal Photonics, Inc. 814**
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**Vigo-System, Ltd. 1015, 1017**
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Manufacturer of HgCdZnTe IR detectors. Our photovoltaic designs operate at or near room temperature and provide the best solutions for high-speed detection from 2 to 11+ microns.

**Vincent Associates 727**
Rochester, NY

**Vision Systems Design 825, 827**
**PennWell Publishing Company**
Nashua, NH
A monthly magazine serving engineers, engineering managers, and corporate managers who design vision and imaging systems.

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Products include: KineView™ high-speed video systems, monolithic lenslet modules, Hartmann wavefront sensor hardware and software - the Advisor™ Web Inspection System.

**Advanced Imaging Magazine 311**
**PTN Publishing Co.**
Melville, NY
Advanced Imaging is dedicated to providing the latest information on imaging hardware, software, and peripherals to qualified professionals.

**Alacron Inc. 334**
Nashua, NH
Designs, develops, and manufactures high-performance computing subsystems for demanding imaging applications.

**Alden Electronics Inc. 624**
Westborough, MA

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**Amerinex Applied Imaging, Inc. 620, 622**
**Imaging Products Division**
Amherst, MA
Provides software development tools, DLLs and ActiveX components for rapid prototyping and deploying applications needing image processing.

**Basler Vision Technologies 515**
**Components & Solutions**
Ahrensburg, Germany

**Birkhaeuser Publishers 615**
Cambridge, MA
Birkhaeuser presents new books in computational sciences. Visit our booth for 20% discount on all titles on display.

**CIDTEC 520**
Liverpool, NY
Develops and manufactures a full line of high-performance charge-injection-device (CID) solid-state video cameras and sensors.

**Cohu, Inc. 321, 323**
**Electronics Division**
San Diego, CA
Manufactures color and monochrome CCD cameras for machine vision and process control. American made and ISO-9001 certified.

**Coreco Inc. 408, 410**
Ville St. Laurent, Quebec, Canada
Cobra/C6, a powerful image acquisition and processing engine targeted for high-end machine vision applications.

**CRL-Central Research Labs 209**
Middlesex, UK

**Dalsa Inc. 407**
Waterloo, Ontario, Canada
Our new Piranha line scan CCD camera family features high sensitivity and 100 MHz data rates.

**Datacube, Inc. 322**
Danvers, MA
New Technology Disk (NTD) software enables high-bandwidth (70 MB/sec) digital image recording and playback with virtually any camera.

**DigiVision, Inc. 433**
San Diego, CA

**Dipix Technologies Inc. 424**
Ottawa, Ontario, Canada
Designs and manufactures innovative lines of vision products, ranging from framegrabber and image-processing boards for PCs to large end-user system solutions.

**Duncan Technologies 307**
Auburn, CA

**Eagle-Picher Industries, Inc. 304**
**Electro-Optic Materials Dept.**
Quapaw, OK
Products manufactured: germanium tetrachloride, germanium dioxide, UHP germanium metal, germanium and silicon infrared optical material, gallium sesquioxide and more.

**Eastman Kodak Co. 312**
**KEMD Optical Products**
Rochester, NY
Molded glass and plastic lenses, standard elements, catalog, various focal lengths, materials, coatings, and mount options available.

**Eastman Kodak Co. 314, 316**
**Motion Analysis Systems Division**
San Diego, CA
The Kodak Ektapro HG Imager Model 2000 is the next generation in a family of compact cameras that combine high frame rates and excellent-resolution digital imaging.

**EEV, Inc. 320**
Elmsford, NY
CCD sensors for spectroscopy, space (x-ray, near-IR, and invisible), astronomy, high-energy physics, machine vision, defense, and medical imaging.

**Epix, Inc. 722**
Buffalo Grove, IL
Manufacturer of PCI and ISA bus image processing hardware and software for automated inspection/sorting, quality control, measurement, and scientific/medical imaging.

**Fostec, Inc. 420, 422**
Auburn, NY
Fostec manufactures fiber optic components and illumination systems for machine vision, microscopy, and laboratory applications.

**Germanow-Simon Corp. 427**
Rochester, NY
Our custom plastic optics with aspheres, diffractives, Fresnels, or mirrors are used in sensing, scanning, imaging, and detecting applications.

**Hitachi Denshi America Ltd. 204, 206, 208**
Woodbury, NY

**Image Content Technology 332**
New Britain, CT

**Imaging Technology, Inc. 330**
Bedford, MA
Provider of solutions for all of your high-performance machine vision needs. Manufactures vision hardware and software components and systems for OEM systems integrators.

**Incom, Inc. 326**
Charlton, MA
Manufacturer of fiber optic faceplates for CCD arrays, LCDs, image intensifiers and CRTs, for industrial and medical applications.

**IO Industries 308**
London, Ontario, Canada
Software features real-time video recording to disk or system memory, supporting standard or nonstandard video.

**Lasiris, Inc. 216**
St. Laurent, Quebec, Canada
Offeris a complete line of laser-based structured light projectors for machine vision and alignment.

**Logical Vision Ltd. 408, 410**
Burnaby, British Columbia, Canada
Logical Vision will display WiT 5.2, the first product to combine multiple Pentium execution with MMX-based image processing operations.

**The MathWorks, Inc. 327**
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**Matrox Electronic Systems Ltd. 521, 523**
**Imaging Products Group**
Dorval, Quebec, Canada
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**Mercron Inc. 309**
Richardson, TX

**Mikron Instrument Co. Inc. 437, 439**
Oakland, NJ
Mikron's Model TH5104, a new low-cost, portable infrared thermal imager, is ideal for process and maintenance applications.

**MiroTech Microsystems Inc. 626**
St. Laurent, Quebec, Canada
Focused on supplying DSP design markets with reconfigurable computing solutions.

**MuTech Corp. 306**
North Billerica, MA
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**National Instruments 421, 423**
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**Noesis Vision Inc. 522**
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Visilog 5.1, its latest and best imaging software for Windows 95 and UNIX.

**Optima Inc., Japan 526**
Elk Grove Village, IL

**Photographic Solutions, Inc. 613**
Buzzards Bay, MA

**Princeton Instruments, Inc. 412**
Trenton, NJ
A complete line of systems for optical and x-ray spectroscopy and imaging, including the widest selection of CCD-based detectors and cameras.

**Pulnix America, Inc. 525, 527**
Sunnyvale, CA
An extensive line of off-the-shelf and custom CCD cameras. Features include progressive scan, high speeds, internal frame memory and digital output.

**Redlake Imaging Corp.** **426**
Morgan Hill, CA
Manufacturer of the MotionScope™ high-speed imaging product line for R&D, quality control, and predictive and preventative maintenance.

**Research Systems, Inc.** **205**
Boulder, CO
IDL, the Interactive Data Language, is the ideal software for data analysis, visualization, and application development. IDL's features include interactive 2D and 3D graphics, and object-oriented programming.

**Rodenstock Precision Optics, Inc.** **431**
Rockford, IL
Designer and manufacturer of laser, photographic, x-ray lenses, and optical components for visible and infrared industrial, and scientific applications.

**Sine Patterns LLC** **621**
East Rochester, NY
Specializes in photographic sinusoidal test patterns as either stock or custom items. The stock items include single-frequency targets and test pattern arrays.

**Sony Electronics Inc.** **415**
Park Ridge, NJ
Exhibiting over 20 different models of image capture and sensing cameras in many categories.

**Special Optics Manufacture & Design** **414, 416**
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Designs, manufactures standard and custom optical components. Products include fixed and zoom beam expanders, IR optics, diode collimators.

**Spectral Instruments Inc.** **716, 718**
Tucson, AZ
Designs and manufactures CCD-based analytical instruments. Products include low-noise 12- to 16-bit CCD-based camera systems.

**Tartan Technical, Inc.** **217**
Tyngsboro, MA
A value-added reseller of digital input and output equipment for the leading manufacturers.

**Team Systems Inc.** **220**
Santa Clara, CA
Brand new high-performance ASTRO VG-851/854 video generator: max. 400-MHz pixel frequency; max. 300-kHz horizontal scanning.

**Texas Instruments Inc.** **710, 712**
**Mixed Signal Imaging Solutions**
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Will display a full line of area array CCD image sensors and support circuits, and demonstrate a high-performance analog-front-end device.

**Texas Memory Systems, Inc.** **305**
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**Thomson Components and Tubes Corp.** **425**
**TCS Division**
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Charged-coupled devices for scientific, medical, and industrial applications. Line scan, frame transfer and full-frame devices are available.

**Toshiba America Information Systems, Inc.** **325**
**Imaging Systems Division**
Irvine, CA
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**Varian Associates, Inc.** **404, 406**
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Cary UV-VIS spectrophotometers combine excellent optical performance, rugged hardware, and our newly released Cary Win UV software.

**VisiCom Imaging Products** **313, 315**
San Diego, CA
PCI, PMC, VME and Sbus video, imaging, and graphics boards for real-time embedded applications.

**Xerox Imaging Standards** **324**
Rochester, NY
Imaging Standards test patterns and special services are used by scientists and engineers in the electronic copying and printing industry.





For More Information Circle No. 461

# Delta-Doped Hybrid Advanced Detector

## This device could detect both particles and photons over wide energy ranges.

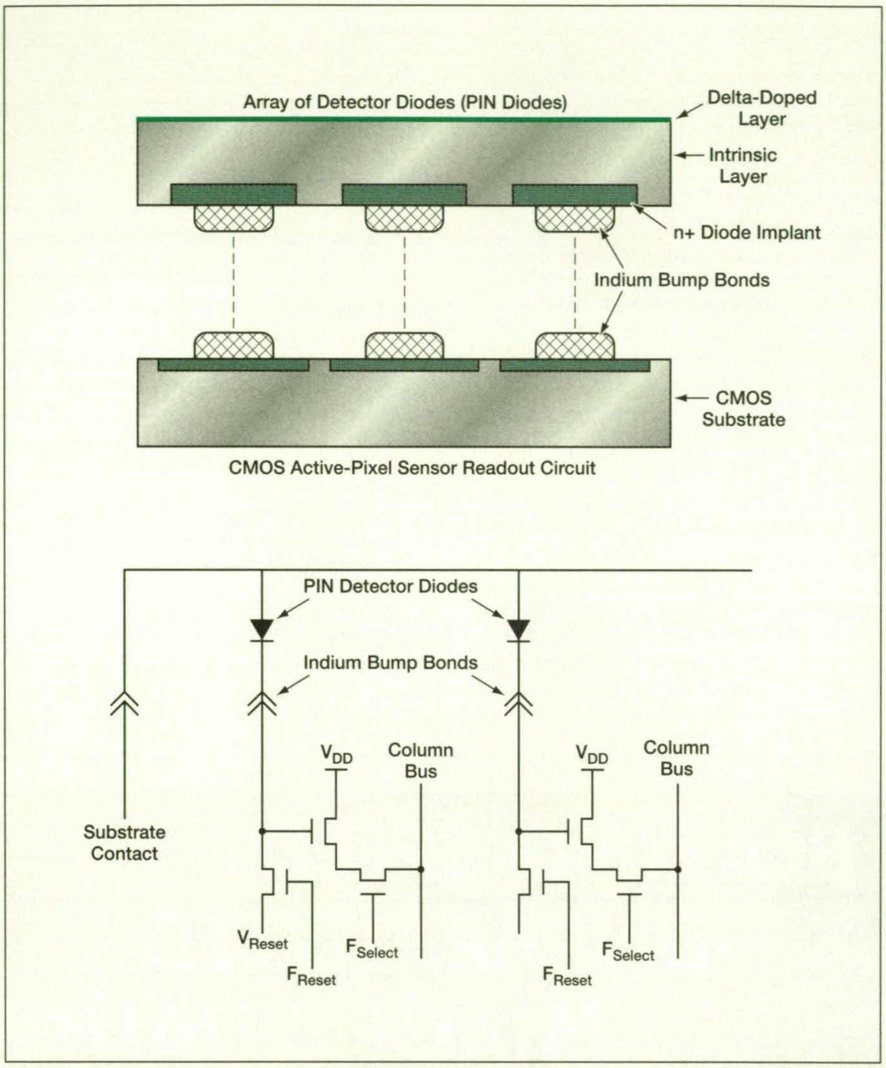
*NASA's Jet Propulsion Laboratory, Pasadena, California*

The delta-doped hybrid advanced detector is a developmental integrated electronic imaging and detecting circuit designed to be sensitive to (1) charged particles with kinetic energies ranging from hundreds through millions of electron volts and (2) photons ranging from visible light to x rays. Heretofore, the lower kinetic-energy limit of detectability of charged particles has been about 10 keV. To extend the limit downward to hundreds of electron volts, the design of the delta-doped hybrid advanced detector calls for a combination of features from several recent lines of development of detector and readout circuits.

The detector would be a hybrid of (1) a square array of reverse-biased positive/intrinsic/negative (PIN) diodes with (2) a correspondingly patterned complementary metal oxide/semiconductor (CMOS) integrated readout circuit fabricated by a standard process. The array of PIN diodes would be electrically and mechanically connected to the readout circuit through indium bump bonds (see figure).

In a reverse-biased PIN diode, the applied electric field depletes the intrinsic region of charge carriers. When an energetic charged particle or photon of sufficient energy enters the depletion region, some or all of its energy is dissipated in the generation of electron/hole pairs, which are then swept out by the electric field and detected. However, low-energy particles typically do not penetrate to the intrinsic region in a conventional PIN diode. Instead, they tend to dissipate their energies in a "dead" layer near the surface through which they enter. The dead layer contains an undepleted, highly p- or n-doped, diode contact sublayer where electrons and holes recombine before they can be detected. The dead layer also contains a surface depletion sublayer with an electric field that (a) tends to confine some charge carriers until they recombine at the surface and (b) drives other charge carriers into the undepleted region, where they recombine before detection.

The delta-doping aspect of the delta-doped hybrid advanced detector would extend the low-energy detection limit by reducing the effect of the dead layer. Delta doping is so named because its density-vs.-depth characteristic is reminiscent of the Dirac d function (impulse function). The dopant is concentrated in a very thin layer (preferably, a single atomic layer). In the delta-doped hybrid advanced detector, the delta-doped layer would be placed within 5 or 10 Å of the detector surface. The delta-doped layer would provide a very thin undepleted region and surface depletion region, with a resultant dead-layer thickness of only 15 to 20 Å, making possible the collection of electrons and holes generated by low-energy charged particles and photons that can penetrate at least 20 Å or so.




**Detector Diodes Would be Joined With CMOS Readout Circuitry** by use of indium bump bonds. Pixels could be raster-scanned or read out nonsequentially. The column signal-processing circuitry would enable the incorporation of correlated double sampling or other advanced features.

Heretofore, delta doping has been used on charge-coupled devices (CCDs). Although CCDs could be used as detectors, they are relatively highly doped; it would be necessary to thin them to enable their charge-collecting depletion regions to extend through the thickness. Thinning can be accomplished only by a difficult fabrication process step, and the remaining thickness is not sufficient for measuring the energies of x rays and high-energy particles that deposit charge carriers at great depths. Accordingly, the array of PIN diodes in the delta-doped hybrid advanced detector are made from a wafer of high-resistivity silicon [nominally intrinsic, though actually very lightly p-doped (to a concentration of $10^{12}$ $cm^{-3}$)] like that used in silicon strip detectors. The use of this high-resistivity silicon makes thinning unnecessary, thereby making it possible to retain sufficient thickness for detection of highly energetic charged particles and photons.

The CMOS readout circuit would be of the active-pixel sensor (APS) type, offering enough sensitivity to enable res-

olution of the small signals generated by low-energy charged particles. This circuit would consume only milliwatts of power, in contradistinction to a CCD, which typically consumes watts. Moreover, whereas a CCD must be read out sequentially by rows and columns, the APS circuit would be capable of nonsequential readout of pixels, making it possible to use various advanced readout schemes. Like a CCD, this readout circuit could preserve the low capacitance of the detector diodes, with resultant readout noise of 10 electrons or less (vs. hundreds to thousands of electrons for a conventional strip detector).

A pixel-guarding technique would be used to preserve low effective input capacitances for the APS readout circuit, even in the presence of relatively large indium bump pads on the input nodes, thereby preserving the high conversion gain needed for high sensitivity and a high signal-to-noise ratio. In this technique, each bump bond would be connected to a source follower serving as a unity-gain buffer, the output of which would be fed to a metal guard electrode underneath the bump bond and separated from the bump bond by a thin insulating layer.

*This work was done by Eric Fossum, Thomas Cunningham, Shouleh Nikzad, George Soli, and Bedabrata Pain of Caltech for* **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronics Components and Circuits category.*

*In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to*

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*Refer to NPO-20111, volume and number of this* NASA Tech Briefs *issue, and the page number.*

# Fabrication of Diffractive GaAs Microlenses

## Relief patterns are made by electron-beam lithography, then transferred by plasma etching.

*NASA's Jet Propulsion Laboratory, Pasadena, California*

A planar array of microscopic diffractive optical elements that resemble macroscopic Fresnel lenses can be fabricated as an array of continuous relief patterns on a GaAs substrate by a procedure that includes the transfer of a corresponding array of patterns formed on a surface layer of poly(methyl methacrylate) (PMMA) by electron-beam lithography. The diffractive optical elements could be, for example, microlenses on back-side-illuminated imaging arrays of GaAs-based quantum-well infrared photodetectors (these microlenses are used to concentrate incident infrared light into sub-pixel-size active device areas). The fabrication procedure is not limited to arrays of microlenses; it can also be adapted to making other optical elements (for example, holograms or diffractive macrolenses) in GaAs.

A GaAs substrate to be patterned is first coated with PMMA to a suitable thickness (e.g., 2 µm). A pattern corresponding to an approximation of the desired surface relief pattern on GaAs is written in the PMMA by a scanning electron-beam apparatus, with local electron-beam dosage pixelized on a grid of suitably high resolution (e.g., 1-µm-square cells). The local electron-beam dosage to the PMMA must be varied to obtain the desired final local variation of surface height of the GaAs substrate, taking account of the effects of subsequent processing steps, including such complicating effects as nonlinear dose-vs.-depth relationships and back-scattering of the electron beam from previously written nearby areas. The exposed PMMA is then developed by spinning the coated substrate and spraying acetone down onto it, yielding an intermediate surface relief pattern on the PMMA. The total development time is usually about 10 seconds, and depths are usually accurate to within ±5 percent.

The surface relief pattern on the PMMA is transferred to the underlying GaAs by plasma etching. The PMMA-coated substrate is placed in an electron-cyclotron-resonance system, wherein it is cooled to 10 °C and etched, using Ar and $BCl_3$ as process gases. The chosen

combination of process gases and physical processing conditions yields an advantageously high GaAs/PMMA etch ratio.

*This work was done by Frederick Pool, Daniel Wilson, Richard Muller, and Paul Maker of Caltech for* **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Manufacturing/Fabrication category.*

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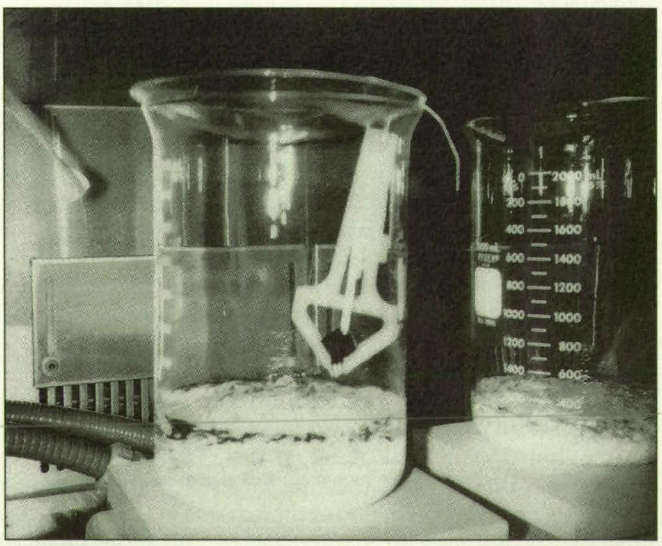
# Vapor Drying for Preparing InGaAsP for Epitaxial Regrowth

## Traces of water and other contaminants are removed in a three-step treatment.

*NASA's Jet Propulsion Laboratory, Pasadena, California*

A vapor drying treatment removes traces of water and other contaminant residues that remain on the surface of a patterned semiconductor substrate after chemical cleaning in preparation for subsequent epitaxial growth on the substrate. The treatment was developed in conjunction with attempts at epitaxial regrowth of first-order gratings for distributed-feedback lasers in the InGaAsP material system.

A chemical cleaning typically ends with a rinse in deionized water followed by drying in isopropyl alcohol vapor followed by



A **Simple Vapor Degreasing Still** can be made with a 2,000-mL beaker of Pyrex (or equivalent) low-thermal-expansion glass. The bottom of the beaker is covered with polytetrafluoroethylene boiling stones, 600 mL of an organic solvent is brought to a boil, and a cover glass is placed over the top. The substrate to be treated is mounted on a polytetrafluoroethylene holder and lowered into the vapor space through a slit in the cover glass.

blow drying with nitrogen. Notwithstanding the apparent thoroughness of the drying steps, the amount of water and other contaminants that remain on the cleaned surface is sufficient to give rise to a large number of defects in epitaxial material.

The present vapor drying treatment is essentially a modified, three-step vapor degreasing procedure. It was selected from among a number of similar treatments in experiments based on the conjecture that aggressive vapor degreasing might be capable of removing water vapor that sticks to the surface of a substrate after cleaning and conventional drying. In each step of the treatment, the substrate is lowered into a still filled with a solvent vapor (see figure) and kept there for a few minutes.

Of a number of different combinations of vapor dips that were tested in the experiments, the one that proved most successful in removing water vapor from the surface of a cleaned substrate was acetone followed by trichloroethylene followed again by acetone. The trichloroethylene in this combination was initially chosen with the expectation that it would remove any organic residue that would assist in keeping water vapor on the surface. However, since water does not dissolve easily in trichloroethylene, an initial dip in acetone vapor was added to remove as much water vapor as possible from the surface before immersion in trichloroethylene vapor. Furthermore, since acetone easily mixes with trichloroethylene and is more volatile, acetone was also chosen for the final vapor dip, not only to remove trichloroethylene from the surface but also to leave a thin surface layer of solvent that would either quickly evaporate upon

**BEFORE TREATMENT**

| Element | Atomic Percent |
|---|---|
| As | 11.01 |
| Ga | 2.14 |
| C | 45.21 |
| In | 9.57 |
| O | 32.08 |

**AFTER TREATMENT**

| Element | Atomic Percent |
|---|---|
| As | 23.79 |
| Ga | 4.50 |
| P | 11.66 |
| C | 20.14 |
| In | 18.41 |
| O | 21.49 |

The **Composition of the Surface** of an InGaAsP substrate was determined by XPS before and after the treatment described in the text. The treatment caused a reduction in the carbon and oxygen contents and the appearance of phosphorus — all indications of a very clean surface.

removal from the vapor bath, or else would be quickly desorbed upon heating of the substrate to growth temperature.

In the experiment on this treatment, a specimen substrate was first dipped in acetone vapor for 5 minutes to ensure removal of water vapor. Condensation — most likely acetone — was observed on the substrate and substrate holder throughout this step of the treatment. Next, the substrate was placed in trichloroethylene vapor for 5 minutes. Once again, condensation — most likely trichloroethylene — was observed on the substrate. Finally, the substrate was again exposed to acetone vapor to remove the trichloroethylene from its surface and saturate the surface with the more volatile acetone. The substrate was left in the acetone vapor for 5 minutes. Surprisingly, about two minutes into this last step, all noticeable drops of condensation vanished from the substrate and substrate holder, leaving behind extremely dry surfaces.

The precise physical mechanisms responsible for the effectiveness of this three-step vapor drying treatment remain unknown. What is known is that the technique is so effective in drying the surface as to prevent most of the defects that would otherwise form in epitaxially deposited material. Moreover, analysis of a substrate by x-ray photoelectron spectroscopy (XPS) reveals that the three-step treatment reduces the amount of carbon and oxygen contaminating the surface (see table). The remaining carbon and oxygen have been tentatively attributed to exposure of the substrate to air during transfer to the XPS apparatus.

*This work was done by James Singletery, Jr., of Caltech for* **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category.*

*In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to*

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# Noncontacting Resonant Ultrasound Spectroscopy for Nondestructive Evaluation

## A new method utilizes photorefractive frequency-domain processing.

*Idaho National Engineering and Environmental Laboratory (INEEL), Idaho Falls, Idaho*

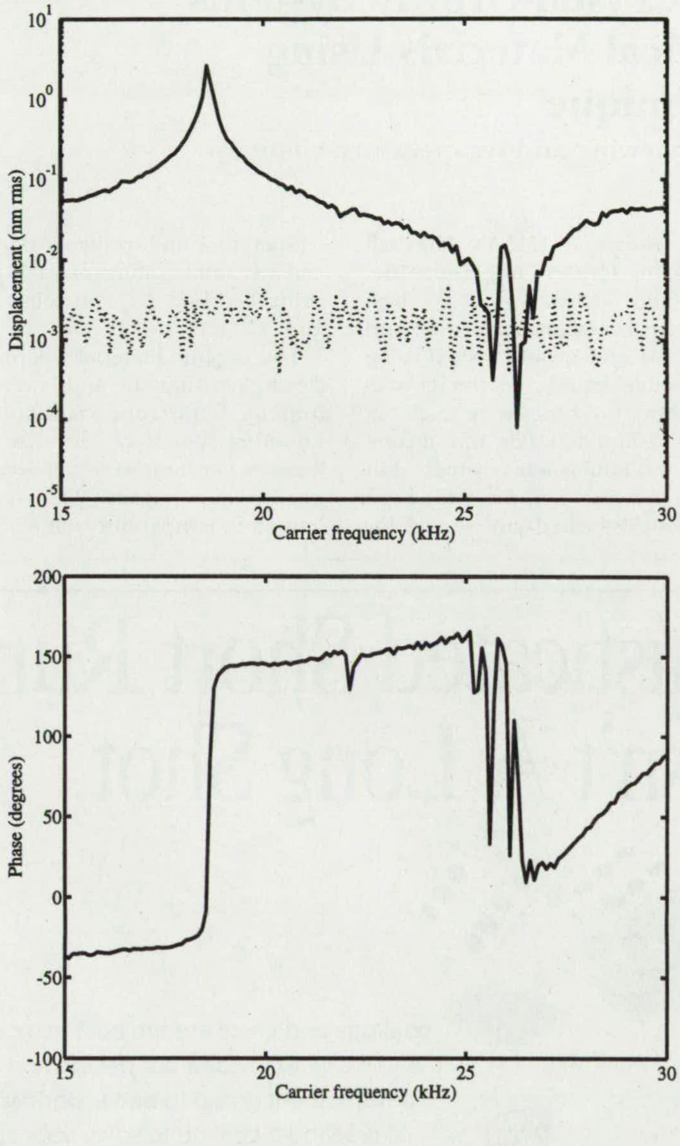
An important nondestructive evaluation (NDE) measurement technique is to record the vibration-mode spectrum of a material part or structure, excited by a random or a driven source (i.e., acoustic coupling or shaker table). The vibration-mode spectrum fully describes the part dimensions and material properties, including defects. Application of this technique has spawned a new NDE method known as resonant ultrasound spectroscopy (RUS) that has been found useful for characterizing components and structures of many diverse shapes and sizes.

At INEEL, a new optical method for implementing RUS analysis based on photorefractive frequency-domain processing has been developed. The method utilizes the photorefractive effect in bismuth silicon oxide for detection of the optical phase shift of an object beam scattered from a vibrating specimen surface. Flat narrow-bandwidth detection can be achieved at frequencies from the photorefractive response limit (~70 Hz) to the reciprocal of the photoinduced carrier recombination time (~10 MHz).

In this approach, all optical interference occurs inside the photorefractive crystal, resulting in an output beam whose intensity is proportional to the Bessel function of order one; therefore, linear for small amplitudes: $2\pi\xi/\lambda<<1$. The method accommodates rough surfaces through the spatial adaptability of the photorefractive effect, which acts as a mixing and low-pass-filtering element, providing the benefits of optical lock-in detection.

Two modes of operation are possible: the power spectrum mode, for asynchronous vibration amplitude measurement, and the swept network mode, for synchronous vibration amplitude and phase measurement in analogy with common electrical spectral analysis methods. Very narrow-bandwidth detection (1 Hz) of the output signal intensity yields a minimum detectable amplitude of about 0.002 nm over the entire operating frequency range. Further improvements in sensitivity are possible and are being investigated. The figure shows the amplitude and phase measured on a vibrating surface




**Vibration Amplitude and Phase** recorded in the swept network mode.

operating around its fundamental resonance.

This method is applicable to full-field views of vibrating structures, thereby providing a significant improvement in sensitivity and speed over the conventional speckle interferometry method. An all-optical implementation, including the vibration excitation, is under development.

*This work was done by Ken Telschow, Thomas Chatters Hale, and Vance Deason at* **Idaho National Engineering and Environmental Laboratory (INEEL)**. *For further information contact Dr. Telschow at (208) 526-1264; E-mail: telsch@inel.gov. Inquiries concerning the rights for commercial use of this invention should be addressed to Michael McIlwain, Technology Transfer Office, INEEL, Idaho Falls, ID 83415-2209; (208) 526-8130. Refer to LIT-PI-192.*

# Versatile Transparent-Melt Crystal-Growth Systems for Organic Nonlinear Optical Materials Using Bridgman-Stockbarger Technique

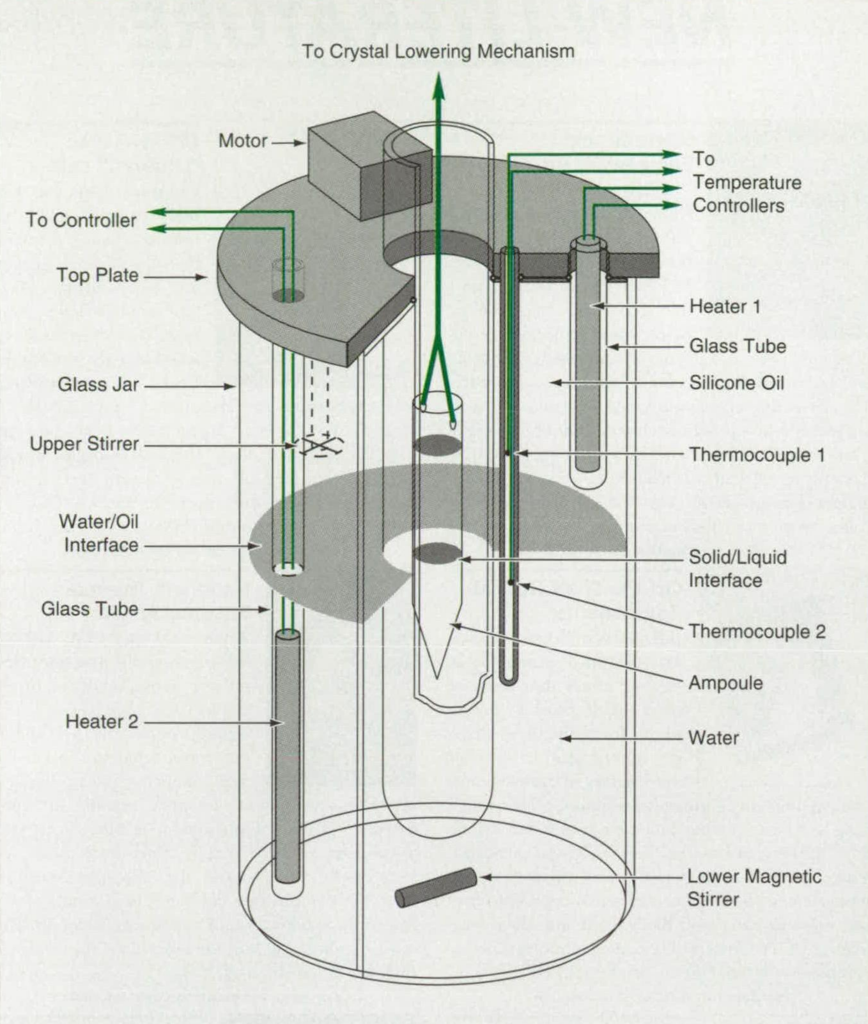
**New crystallization technique allows for viewing and temperature changes.**

*Marshall Space Flight Center, Alabama*

Single crystals of benzil, benzil aniline, and salicylidene-aniline have been successfully grown using a modified Bridgman-Stockbarger technique for three different crystal-growth systems. The unique feature of the Bridgman-Stockbarger technique is that the crystal-melt surface can be viewed from any direction, and the temperature between the hot and cold zones can be adjusted at any time during the melt.

First, scientists at NASA's Marshall Space Flight Center in Huntsville, Alabama, and Alabama A & M University, Normal, Alabama, designed and fabricated the melt-growth system using two immiscible liquids. In this crystal-growth system, two zones were made up of immiscible liquids, water, and silicone oil. These two liquids were contained in a right circular glass cylinder. Each zone was individually heated and stirred for temperature uniformity within the zone, and the temperature of each zone was controlled by a PID controller to within ±0.1 °C.

The organic material was placed in a clean glass ampoule and lowered slowly from the hotter zone to the cooler zone. Lowering speeds of less than 0.2 millimeters per hour were required to grow good-quality crystals. This system was limited to temperatures of 85 °C or less




The **Bridgman-Stockbarger** melt-growth system uses two immiscible liquids.

since one of the zones contained water. Crystals of nonlinear optical material salicylidene-aniline were grown using this system.

To extend the temperature range, a second system was constructed using aluminum end plates and glass walls to contain the heated fluids. Glass cylinders 4 in. (10 cm) in diameter were cut and polished at both ends. An O-ring groove was cut into each end plate and filled with a silicone two-part adhesive. Two separate zones were stacked, one on top of the other. The temperature of each zone was controlled separately by circulating constant-temperature silicone oil using Neslab high-temperature circulating baths.

Also, in this crystal-growth system, a glass conical-tip ampoule was used as a crucible. A conventional crystal-pulling-and-rotation system was used to lower the ampoule through the zones.

Over the last three years, a variety of organic nonlinear crystals have been grown using this melt-growth system.

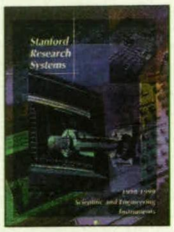
Finally, an all-glass melt-growth system was used for larger diameter bulk single crystals. To alleviate the problem of clear visualization of the growth interface, an all-glass melt-growth system was designed and fabricated in Alabama A & M University's glass-blowing shop.

This system again uses a two-zone system, but was constructed to allow for the growth of larger diameter (25 mm) organic crystals. The temperature was controlled by Neslab constant-temperature baths by circulating silicone oil. A commercial crystal-pulling system was used to lower the ampoule through the zones.

*This work was done by M.D. Aggarwal, W.S. Wang, J. Choi, and Robert Metzl of Alabama A & M University of Normal, Alabama, and Benjamin G. Penn and Donald O. Frazier of* **Marshall Space Flight Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category.*

*Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Council, Marshall Space Flight Center (256) 544-0258. Refer to MFS-26439.*

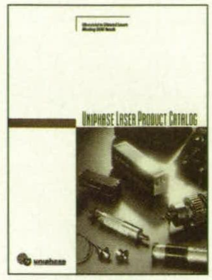
# NEW LITERATURE




## Scientific and Engineering Instruments

The 250-page 1998-99 catalog from Stanford Research Systems, Sunnyvale, CA, has sections devoted to its lines of FFT spectrum analyzers, function generators, high-voltage power supplies, lock-in amplifiers, choppers, and preamplifiers, gated integrators and boxcar averagers, photon counters, and more. The "Scientific and Engineering Instruments" catalog features new products: closed ion source gas analyzers from $5750, gas analysis systems from $23,000, dynamic signal analyzers from $10,950, and transient digitizers from $2000. The catalog closes with 60 pages devoted to application notes.

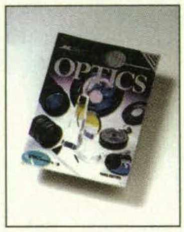
**For More Information Circle No. 685**




## Ultraviolet to "Ultrared" Lasers

Uniphase, San Jose, CA, makes available a 32-page product catalog detailing its lines of HeNe, argon ion, and solid-state lasers and its fiber optics products. These include its solid-state μLasers, StableLight™ diode-pumped solid-state lasers, and NanoLasers, argon-ion lasers, red, green, yellow, and orange HeNe lasers, and custom fiber-coupled diode lasers. Full beam, power, and environmental specifications are given. Regulatory compliance, warranty, and UL-TUV listing information are also included.

**For More Information Circle No. 686**




## Off-the-Shelf Optical Components

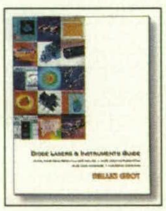
JML Direct, Rochester, NY, says the third edition of its catalog offers thousands of off-the-shelf optical components for immediate delivery. Among products offered are singlets, achromats, mirrors, sapphire and germanium windows, prisms, polarizing and beamsplitting cubes, electronic shutters, filters, diffusers, test targets, Fresnel lenses, cylindrical lenses, thin film coatings, and more. Also included are multi-element systems such as microscope objectives and eyepieces, and laser diode, scan, wide-field imaging and CCTV lenses. Full lens-design information for components is listed on the product pages.

**For More Information Circle No. 687**

## Handheld Thermal Imaging System

Raytheon, Goleta, CA, offers a full-color trifold brochure describing its ExplorIR handheld uncooled imaging system designed specifically for condition monitoring and predictive maintenance applications. Described are the system's features, including a 320-×-240-pixel calibrated uncooled focal plane array with a sensitivity of 0.15 °C. The brochure outlines system configurations and lists all specifications. Graphics demonstrate memory installation, battery insertion, and location of a mouse connection. The mouse utilizes the Windows-like interface on the 5-inch active matrix display.

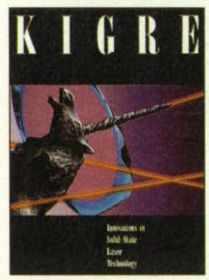
**For More Information Circle No. 688**



## Diode Lasers and Instruments

Melles Griot Electro-Optics, Boulder, CO, has issued a 200-page "Diode Lasers and Instruments Guide" covering optical power measurement and beam analysis, diode laser control and characterization instruments, TE cooler drivers, and nanometric positioning stages, as well as the company's high-performance, free-space, and fibered diode laser assemblies. Beam analysis includes instruments for the measurement of beam intensity profiles, beam position, wavefront phase aberrations, and optical spectra. The guide includes tutorials and practical advice for the electro-optics professional.

**For More Information Circle No. 689**




## "Workhorse" Nd:YAG Laser System

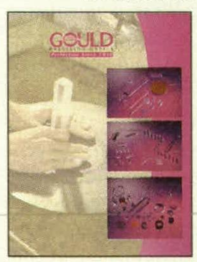
Kigre Inc., Hilton Head, SC, has issued a specification sheet on its Model 1732, a pulsed Nd:YAG laser system with a $TEM_{00}$ beam profile that the company has dubbed the "Workhorse." Six wavelength options are available: 1.57 and 1.06 μm, and 532, 355, 266, and 213 nm. Three energy options are available: 200 mJ per pulse at 50 Hz, 100 mJ at 100 Hz, and 50 mJ at 200 Hz. Beam diameter at 1.06 μm is specified at less than 1 mrad, and for the other outputs approximately 1 mrad.

**For More Information Circle No. 690**

## Laser Power Measurement Instruments

Coherent-Ealing Catalog Division, Auburn, CA, releases a 32-page booklet devoted to its power and energy meters. Included are an introduction to power and energy measurement, and descriptions and specifications of products ranging from the LaserCheck handheld laser power meter and LaserMate laser power and energy meters to the Ultima LabMaster laser power and energy analyzer system for "smart sensors." A section on combined power, position, and digital multimeter measurements includes an introduction to optical multimeter measurements and specifications for the new LaserLab optical multimeter.

**For More Information Circle No. 691**



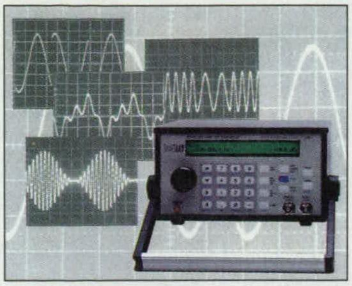

## Custom Precision Optics

Gould Precision Optics, Binghamton, NY, describes its capabilities in a six-page full-color brochure. The company manufactures custom cylindrical optics for a number of applications such as laser research, microlithography, and scanning systems, with surface qualities exceeding 10-5 scratch/dig, and testing interferometrically to 1/5 wave or better. Flat optics with attainable surface roughness of 1 angstrom RMS are available in round, rectangular, elliptical, odd-shaped, coated, and uncoated configurations, for windows, beamsplitters, mirrors, bandpass filters, and more.

**For More Information Circle No. 692**

# NEW PRODUCTS

## PRODUCT OF THE MONTH



### 20-MHz Benchtop Signal Generator

Berkeley Nucleonics Corp., San Rafael, CA, says the Model 625A SmartARB function, pulse, and arbitrary waveform generator was designed to provide more operating modes, more functions, and more measurement modes than any other unit in its price class. The arb clock is fully synthesized, unlike a clock generated by a DDS phase accumulator, which can result in phase jitter and missed points when the arbitrary waveform frequency is changed. The 625A's modes include standard sine, square, ramp, triangle, and random waveforms, but also AM, FM, PM, SSB, FSK, BPSK signal modulation, DTMF generate, DTMF detect, voltage and power measurement, and data and word generation. A DC operation option allows the user to use a power source from 9-36 VDC, suitable for portable and remote applications.

**For More Information Circle No. 770**

### Custom Laser Enclosures

Velmex Corp., Bloomfield, NY, introduces custom laser enclosures constructed with the MiniTec modular aluminum T-slot profile framing system. The company says the PowerLock connector enables quick assembly of framing elements without access holes. The elements do not hinder panel placement. Hundreds of matched accessories are offered, including swinging, sliding, or counterweighted doors, handles, and hinges. Accessories attach to the T-slots (8.2 mm ±0.2) with standard screws and nuts. Several profile cross-section sizes are available in lengths up to 6 m.

**For More Information Circle No 771**

### Digital Imaging Camera Chip

Amain Electronics Co., Simi Valley, CA, says that it has produced the largest array of analog-to-digital converters ever manufactured: 307,200 converters on one microchip. The 12-bit converters are spaced on 27-micron centers in a 640-×-480 array. New technology developed by Amain, called MOSAD™ (multiplexed oversample analog-to-digital conversion), is intended for digital video imaging applications. Amain says that the photon-to-digital conversion technology at each pixel is also a new approach, creating a new digital data format that may be used in display applications to reduce costs.

**For More Information Circle No. 772**

### Compact Laser Marking System

The new LP-101 carbon dioxide laser marking system from SUNX Sensors, West Des Moines, IA, is the smallest laser marker available that is capable of permanently marking materials from paper, wood, and plastic to resins, ceramics, and glass, in a 90-×-90-mm marking area, according to the company. Using an FDA-approved Class 4 carbon dioxide laser, the LP-101 system includes a handheld LCD touch panel with back-light display, laser head, and controller. It is fan-cooled, requiring no water cooling. Its controller will store up to 99 programs.

**For More Information Circle No. 773**

### High-Rep-Rate Joulemeter

Molectron Detector Inc., Portland, OR, calls its Model EPM1000 joulemeter, which can now measure pulse-to-pulse energies to 1.2 kHz, the world's fastest joulemeter. The user can download every pulse to a PC through the RS-232 or IEEE-488 communication ports. Molectron's patented pyroelectric detectors will measure energy from 100 nJ to 100 J, DUV to far IR. The user can view minimum, maximum, average, and standard deviation of up to 10,000 pulses.

**For More Information Circle No. 774**

### High-Speed Video Capture System

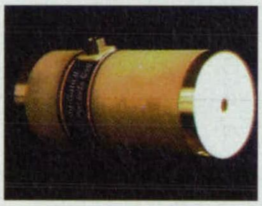
Redlake Imaging, Morgan Hill, CA, combines its proprietary monochrome digital camera head incorporating a solid-state high-speed shutter, a full-size PCI board, cabling, and Redlake's MotionScope™ software in its typical system. It can record up to 8000 images per second using shutter speeds up to 1/40,000th of a second, with resolution up to 480 × 420 × 8-bit pixels per frame, depending on the model. Manual triggering or optical, acoustic, or other sensors can be used to control the recording sequence. The system requires a 200-MHz Pentium-based PC with at least 64 Mbytes of RAM and a 3-GB hard drive and Windows 95 or NT 4.0.

**For More Information Circle No. 775**

### Large-Area Avalanche Photodiodes

Advanced Photonix, Camarillo, CA, calls its 571 Series cooled-head large-area avalanche photodiodes (LAAPDs) solid-state replacements for photomultiplier tubes in many low-light-detection applications. The company says the series typically delivers a gain of 300, roughly four times that of other APDs, over a spectral range of 350 nm to 850 nm. LAAPDs offer quantum efficiencies of up to 90%, while 10-25% is typical of PMTs, according to Advanced Photonix. Active-area diameters of 5, 10, and 16 mm are available. An optional module incorporates a power supply, TEC controller, and low-noise preamplifier into a single compact enclosure for plug-and-play.

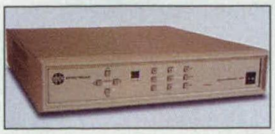
**For More Information Circle No. 776**



### BBO Pockels Cell

Cleveland Crystals Inc., Cleveland, OH, says its new Light-Gate Pockels cell offers high-power DPSS laser manufacturers a compact, high-performance alternative to acousto-optic and electro-optic Q-switch technologies. With damage resistance similar to KD•P devices, the Light-Gate has reduced potential for thermal lensing, the company says. Special damage-resistant ceramic aperture plates prevent illumination of nonoptical components. The device employs two transverse-field BBO elements for a DC quarter-wave voltage of 2.8 kV at 1064 nm.

**For More Information Circle No. 777**



### Display Signal Synchronizer

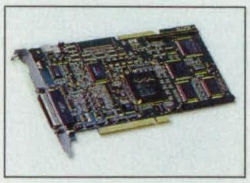
RGB Spectrum, Alameda, CA, announces the SynchroMaster® 350, a signal synchronizer designed to switch seamlessly between asynchronous signals, particularly for applications in large-format projection. When presenting information from multiple computers on a large-screen device, the SynchroMaster solves the sync problem by rescanning all inputs to a common output signal, which can be locked to an external reference signal or selected by the user. The system offers instantaneous clean cuts between any RGB signals, as well as fade-ins and fade-outs, pan-and-zoom, and freeze of any input signal.

**For More Information Circle No. 778**

### Laser Eye Protection

Trinity Technologies, Minneapolis, MN, offers a new line of HVP™ laser eye protection. The company says the HVP line incorporates advanced filter technology that blocks the laser wavelengths while allowing beneficial visible light to be transmitted at 90% or greater, vastly improving visibility, color recognition, and eye safety. HVP laser eye protection is offered for a variety of single- and multi-laser environments, including 532/2064 nm, 690-2940 nm, 580-605 nm, 630-830 nm, 800-1600 nm, and others. Trinity also designs custom HVP filters.

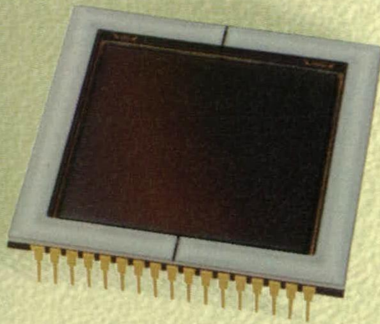
**For More Information Circle No. 779**



### RGB/Monochrome PCI Framegrabber

Matrox Electronics Systems Ltd., Dorval, Quebec, Canada, announces availability of the Meteor-II multichannel PCI framegrabber that can digitize video from a variety of cameras including progressive-scan devices. Features include a PCI bus master interface, on-board memory up to 4 MB, trigger input, RS-232 serial communication and power output, and a custom ASIC for pixel formatting. Transfers to host memory for processing or VGA memory for visualization occur without continuous host intervention at sustained rates of up to 130 MB/second.

**For More Information Circle No. 780**



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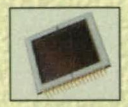

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# TECH EAST '98

## EXHIBITS PREVIEW

Tech East '98 is an alliance of six major high-tech events, in one place, at one time. Held in Boston's Hynes Convention Center from November 3-5, Tech East combines: Technology 2008, the New England Design & Manufacturing Expo, the Small Business Tech Expo, the National Small Business Innovation Research (SBIR) Conference, Photonics East, and Electronic Imaging International. The following pages preview some of the 400+ Tech East exhibits. Visit **www.techeast.net** for detailed floor plans of the exhibit halls.

### Technology 2008

This ninth annual National Technology Transfer Conference is America's premier showcase of new and next-generation technologies available for license and commercial development. (Sponsored by *NASA Tech Briefs* magazine, the Technology Utilization Foundation, and the Federal Laboratory Consortium)

**Advanced Modular Power Systems — Booth 2110**
Ann Arbor, MI

**Alacron Inc. — 2120**
Nashua, NH

**Argonne National Laboratory — 2619**
Argonne, IL

Argonne National Laboratory is a research and development laboratory located 25 miles southwest of Chicago, with 200 programs in basic and applied sciences. The technology transfer group helps move technologies into the marketplace.

**Austrian Trade Commission — 2118**
New York, NY

The Austrian Trade Commission promotes trade and mutual cooperation between the U.S. and Austria, and helps in identifying market opportunities, technology transfers, and similar arrangements.

**BFGoodrich Aerospace — 2221**
Vergennes, VT

Headquartered in Akron, Ohio, BFGoodrich is a broad-based supplier of aircraft systems and services, providing both initial production and replacement products for commercial and military applications.

**Boston University Photonics Center — 3202**
Boston, MA

The Photonics Center forges true business partnerships with investors and industrial partners to turn engineering concepts into commercial products.

**Brookhaven National Laboratory — 2718**
Upton, NY

Brookhaven's booth will feature their new planar optic display, as well as examples of basic and applied research in the physical, biomedical, and environmental sciences, and in selected energy technologies for commercialization.

**Bureau Veritas Quality International — 2104**
Providence, RI

BVQI, part of a worldwide corporation, provides value-added registration services to ISO-9000, ISO-14000, AS9000, SA 8000, and QS-9000 to a multitude of industries.

**CELS — Corning Laboratory Services — 2121**
Corning, NY

CELS provides analyses of materials for customers on a confidential basis. This includes chemical analysis, physical and mechanical property measurements, electrical property testing, and defect analysis.

**Centro Estero Camere Commercio Piemontesi — 2411**
Torino, Italy

Assists Piedmontese companies in finding trade and technology transfer opportunities abroad, and the converse.

**Dexter Magnetic Materials — 2520**
Billerica, MA

Dexter provides permanent magnet solutions for inductive recording heads, microwave switches, radar detectors, magnetic bearings, plasma containment, navigational systems, mass spectrometers, and more.

***Discover* Magazine — 2521**
New York, NY

*Discover* Magazine is now accepting nominations for the 10th Annual Discover Awards for Technological Innovation, with a $100,000 prize.

**Edge Tech — 2518**
Milford, MA

Edge Tech Moisture and Humidity Systems (formerly EG&G) designs, manufactures, and markets sensor-based instrumentation that measures moisture and humidity in air and other gases.

**E. FJELD Co. Inc. — 2204**
Billerica, MA

Will introduce a reconditioned scanning electron microscope equipped with digital imaging and energy dispersive X-ray analysis, offering significant cost savings in a PC-based package; a high-resolution, motorized specimen stage ideal for scanning electron microscopes; and an Airlock Transfer Station for vacuum applications.

**Face International Corp. — 2418**
Norfolk, VA

THUNDER™ technology offers a powerful new family of robust, rugged, piezoelectric actuators and sensors, with ultra-high displacement, force, and life expectancy.

**Farlight — 2108**
Torrance, CA

High-definition remote illumination systems integrate task and signal lights, illuminators, fiber optic cable, and unique beamformers for use in applications that require shaped light with specific angular distribution, uniformity, and distinct cut-off.

**Federal Laboratory Consortium — 2618**
Cherry Hill, NJ

The FLC is the nationwide network of federal laboratories that provides the forum to develop strategies and opportunities for linking technology with the mission and the marketplace.

**Fieldworks Inc. — 2722**
Eden Prairie, MN

FieldWorks WorkStations® are rugged, mobile platforms for demanding field environments. All are easily equipped for customer-specific solutions including data acquisition, communications, telemedicine, mapping, and field service.

**Fisher Space Pen Co. — 2218**
Boulder City, NV

The original Fisher Space Pen will write in extreme temperatures and at any angle, even upside down.

**FLC State and Local Government Committee** **2515**
Idaho Falls, ID

Promotes productive interaction among federal laboratories with state and local government and industry to include the exchange of information, technical assistance, and advice to foster sustainable development.

**Hardric Laboratories** **2720**
North Chelmsford, MA

Hardric will display HardZap lightweight metal mirrors for laser systems, as well as new products for $CO_2$ and YAG lasers, mirrors that withstand 100+kW/cm² CW uncooled, and precision fabrication services.

**Harmonic Drive Technologies** **2712**
Peabody, MA

Manufactures zero backlash, high ratio actuators, gearheads and component gear sets for the aerospace, semiconductor, machine tool, and factory automation industries.

**Haydon Switch & Instrument** **2612**
Waterbury, CT

Will exhibit subfractional horsepower stepper motors, linear actuators, linear/rotary dual-motion actuators, pancake motors, and gearmotors.

**Inframetrics** **2107**
North Billerica, MA

Will feature their new uncooled infrared system, ThermaCAM® Ultra X-95, designed specifically for temperature measurement applications.

**Ingenieurschule Biel** **2208**
Biel, Switzerland

The Biel Institute of Technology is looking for reseller or licensing partners for awarded chip and board test system. Bern Institute of Technology offers optimization of product development and manufacturing processes with the aid of interactive simulation by means of virtual reality methods.

**Invention Machine Corp.** **2219**
Boston, MA

**InVironmental Integrity** **3208**
Minneapolis, MN

The company develops environmental conditioning systems using a patented, electrostatic liquid vaporization method. Applications include disinfection and odor control.

**Launchspace Publications Inc.** **2420**
McLean, VA

*Launchspace* is the magazine of the space industry, reaching 80,000 professionals. Each issue focuses on significant industry programs and is free to qualified professionals.

**Lawrence Berkeley National Laboratory** **2419**
Berkeley, CA

Berkeley Lab is a major national laboratory with 3,300 employees and an annual budget of over $300 million, with expertise in energy, environment, materials, computing, and biotechnology.

**Managing Intellectual Property** **2319**
London, UK

The company will exhibit magazines and other printed materials dedicated to looking at the practical issues surrounding the exploitation and protection of intellectual property rights.

**MathSoft Inc.** **2610**
Cambridge, MA

Mathcad®, designed for professionals and college/university educators and students, is the leading technical calculation package that lets users integrate math, text, graphs, and live calculations.

**MELCOR Corp.** **2710**
Trenton, NJ

Thermoelectric coolers are environmentally friendly because they are solid-state devices (no CFC). Applications include electro-optics, temperature stabilization, enclosure cooling, and power generation from waste heat.

**Micro Surface Corp.** **2320**
Morris, IL

**MicroGroup Inc.** **2202**
Medway, MA

Manufactures and distributes stainless steel and nickel based alloy tubing. Services include tight tolerance resizing, shape drawing, cutting, finishing and cleaning; fabrication capabilities include forming, grinding, welding, laser services, machining, EDM, and Swiss precision CNC work.

**Morgan Group LLC** **2106**
Boston, MA

Consultants to technology-driven enterprises.

**NASA Marshall Space Flight Center** **2427**
Huntsville, AL

NASA's International Space Station Module features a full-size combination mock-up of the crew's living and working environment. A total of 22 rack units show areas where the international crew will sleep, exercise, relax, plus conduct life science and microgravity experiments focusing on drug design and R&D using protein crystals, which will enhance insights into human health, disease prevention, and treatment to improve the quality of human life on Earth.

**NASA Stennis Space Center SBIR Program** **2123**
Stennis, MS

Representatives from the Center's SBIR Program will be available to discuss participation in its 1999 Phase I contracts as well as the total program.

**NASA Tech Transfer** **2312,2408**
Washington, DC

**National Center for Toxicological Research** **2621**
Jefferson, AR

On display will be scientific research/technologies from the FDA's Health Science Research Center. Opportunities for other agencies, academia, and industry to leverage FDA resources through cooperative and/or collaborative research agreements.

**National Institute of Standards & Technology (NIST)** **3206**
Gaithersburg, MD

NIST works with industry to develop and apply technology, measurements, and standards through its Measurement and Standards Laboratories, Advanced Technology Program, Manufacturing Extension Partnership, and National Quality Program.

**National Security Agency Technology Transfer Program** **2109**
George G. Meade, MD

The National Security Agency has established a formal technology transfer mechanism for openly sharing reasonable technologies with industrial partners as well as academia.

**Naval Surface Warfare Center, Crane Division** **2714**
Crane, IN

**NDCEE/Concurrent Technologies Corp.** **2611**
Johnstown, PA

NDCEE/CTC is commercializing technologies to lower costs and meet critical Defense/Market needs through partnerships with the FLC, the Army Industrial Ecology Center, and UNISPHERE.

**Novespace** **2220**
Paris, France

The exhibit will describe European technology transfer networks established around Novespace, and will feature various technology catalogs.

**Olympus America** **2519**
Melville, NY

Olympus offers videoscopes, fiberscopes, and rigid borescopes that enable inspectors to view interiors of complex machinery such as aircraft turbines, diesel engines, and pipelines, without costly disassembly.

**Potomac Institute** **2606**
Arlington, VA

Dual Use Science and Technology Program: DOD and industry co-develop technologies to meet their needs by sharing research costs, while expanding markets and increasing commercial technologies for use in defense systems.

**Russian Technology Transfer Center** **2512**
Moscow, Russia

The Center presents the technologies of Russian aerospace companies in the fields of sensors, launch equipment, engines, and electronics, as well as information resources about Russian defense technologies.

**TechCity Properties Inc.** **2507**
Kingston, NY

**Technology Access** **2422**
Novato, CA

Publishes newsletters on technology transfer and provides consulting services to help universities, federal laboratories, and industry speed innovation from lab to market.

**The Technology Exchange 2421**
Bedfordshire, England
Non-profit organization dedicated to helping businesses exploit technologies/capabilities more profitably through exchanging profiles and promoting contacts.

**Tiodize Co. 2511**
Huntington Beach, CA
The company offers composite fastener products, composite self-lubricating bearings, solid film lubricants, corrosion coatings, penetrants/lubricants, degreasers, and various special coatings.

**TRI/Austin 3204**
Austin, TX
Research, development, and testing experts in the field of material science. Specialties include composites, adhesives, coatings, foams, and polymer systems. Services include accelerated light testing, reliability/engineering failure analysis, and nondestructive testing.

**U.S. Air Force Research Laboratory 2203**
Wright-Patterson AFB, OH
DOD's largest laboratory will display the latest Air Force technologies with application in human systems, information management, space, aircraft, and structures, as well as information on its technology transition/technology transfer program.

**U.S. Army Soldier Systems Command 2103**
Natick, MA
A myriad of military equipment and technologies will be displayed. Working jointly with industry and academia, they conduct research, development, and engineering of military programs and provide lifecycle management for end items.

**U.S. Department of Agriculture/Agricultural Research Service 2318**
**Office of Technology Transfer**
Beltsville, MD
A wide range of patented technologies available for license and business opportunities will be exhibited.

**U.S. Department of Energy 2614**
**Federal Energy Technology Center**
Morgantown, WV
Program areas include advanced power generation, advanced fuels, advanced R&D, natural gas exploration and production, environmental management, and environmental technologies.

**U.S. Department of Energy 2623**
**Kansas City Plant**
Kansas City, MO
Manufacturing process capabilities include electronic, mechanical, engineered materials, testing and evaluation, and services associated with product development.

**U.S. Department of Energy 2321**
**Office of Coal & Power Systems**
Germantown, MD
R&D mission is to foster development and deployment of advanced, clean, affordable fossil-based power systems and alternative fuels to enhance energy security and achieve domestic and global environmental objectives.

**U.S. Department of Energy 2615**
**Office of Industrial Technologies**
Washington, DC
The DOE's OIT manages a national program designed to increase energy efficiency, reduce industrial and municipal waste, and improve U.S. industry's competitive position in world markets. OIT works directly with industry partners to identify research needs and commercialize new and under-utilized technologies.

**U.S. Department of the Interior/USGS 2303**
Reston, VA
On display will be R&D products related to ecology, water resources, mapping, geographic information systems, geologic hazards, mineral resources, water reclamation, environmental remediation, and data management.

**U.S. Department of Transportation (Federal Highway Administration) 2403**
Washington, DC
Find out the latest on aviation system safety at the FAA or what the FHWA is doing to improve our nation's roads. Learn how and why transportation in America is rapidly becoming intermodal, and how you can learn all about it over the Internet. At the FHWA booths you will learn the science of "light retroreflectivity," see the latest technology to efficiently measure the nighttime visibility of signs, and perhaps discover a partnership opportunity.

**U.S. Marine Corps 2119**
Quantico, VA

**Yahoo Visa 2510**
Framingham, MA

## SBIR Technology Showcase — Tabletop Exhibits (Technology 2008 Exhibit Hall)

The following companies, nominees for the 1998 Small Business Innovation Research (SBIR) Technology of the Year Awards, will display an array of products and licensable technologies developed through the SBIR Program.

**Advanced Refractory Technologies T3**
Buffalo, NY 14207
The company has developed a family of hard coatings using Diamond-Like Nanocomposites (DLN), which have been trademarked Dylyn®. The coatings appear optimally suited for flat panel display application.

**American Superconductor T26**
Westborough, MA

**AstroPower Inc. T25**
Newark, DE
The company is commercializing high-performance, room temperature, mid-infrared detectors and avalanche photodiodes for environmental, industrial, military, and aircraft safety applications.

**Cermet, Inc. T13**
Atlanta, GA

**Duncan Technologies T6**
Auburn, CA
The company will display its multi-spectral imaging camera that combines visible color imaging with two channels of near infrared in a single video camera.

**Emcore Corp. T4**
Somerset, NJ

**Houlton Photonics T27**
Houlton, ME
Exhibiting a low-cost planar surfaced photonics submount for passive optical signal distribution.

**Intelligent Fiber Optic Systems T7**
Los Altos, CA
The company will display grating-based fiber-optic sensor systems.

**k Technology Corp. T23**
Fort Washington, PA

**Lionhearth Technologies T1**
Los Gatos, CA
Lionhearth is building a noninvasive, model-based, image understanding system that can be used for motion capture, which will significantly advance such applications.

**Lithium Power Technologies T10**
Missouri City, TX

**Maxios Laser Corp. T19**
Dublin, CA

**Metal Matrix Cast Composites T15**
Waltham, MA

**MicroStrain T21**
Burlington, VT
Will display a network of miniaturized, intelligent, addressable sensing modules (ASMs) that can be embedded within a composite structure and remotely powered, for applications such as health monitoring of thick composite structures, bridges, dams, and buildings.

**New England Space Works T20**
Framingham, MA

**Onyx Optics T9**
Dublin, CA

**Optomec Design Co.** **T22**
Albuquerque, NM

The company uses the Laser Engineered Net Shaping (LENS™) process for building metal parts directly from computer-generated solid models to produce molds for injection mold tooling applications, and to fabricate embedded sensors in otherwise homogeneous metal structural materials.

**Ormet Corp.** **T8**
Carlsbad, CA

Ormet has developed a new, low-cost, high-performance approach to EMI shielding at the circuit board level.

**Physical Optics Corp., Engineering & Product Div.** **T18**
Torrance, CA

**Picolight Inc.** **T28**
Boulder, CO

**Quantum Magnetics** **T12**
San Diego, CA

**REI Systems** **T17**
Vienna, VA

REI has developed Electronic Handbooks, a distributed object-type management system for heterogeneous environments.

**SeaLite Engineering** **T16**
Cataumet, MA

The company is developing a Stress-Optic laser scanner for use in directed energy, satellite communications, and bar and matrix code reading.

**Silicon Mountain Design** **T24**
Colorado Springs, CO

Under contract with BMDO, Silicon Mountain Design developed a high-speed camera system that can be dynamically programmed to adapt to varying imaging requirements for capturing the output of an optical computer.

**Specialized Analysis Engineering** **T14**
Nashville, TN

**Stress Photonics** **T2**
Madison, WI

The GFP-1000 strain measurement system is an innovative polariscope system for Photoelastic Strain Analysis (PSA) of structures. Incorporating a circularly polarized light projector, CCD camera, and customized software, it provides full-field digital strain information.

**Thermacore** **T5**
Lancaster, PA

The company will describe its work in porous metal cooling of laser diodes.

**WiTech LLC** **T11**
Westlake Village, CA

WiTech is developing high quantum efficiency blue and green light emitting diodes for applications such as large outdoor video signs and replacement of incandescent bulbs in traffic signals.

## Literature Exhibit

Stop by booth 2521 for FREE literature from the following exhibitors.

**Alloy Die Casting** **L3**
Buena Park, CA

**Appliance Manufacturer Magazine** **L6**
Solon, OH

The magazine provides ideas to solve design and manufacturing problems, and addresses concerns of global consumer, commercial, business, and medical appliance industries.

**Applied Robotics Inc.** **L8**
Glenville, NY

Manufacturer of industrial automation accessories, including collision sensors, force sensors, light curtains, quick-connect systems, grippers, and vacuum.

**Bulb Direct** **L2**
Pittsford, NY

**Dartmouth College** **L7**
Hanover, NH

Technologies are available for license in the areas of engineering, biotech and medical devices, environmental clean-up, and agriculture.

**Goodfellow Corp.** **L1**
Berwyn, PA
Product Guide gives an overview of the metals and materials available from Goodfellow in small quantities for R&D applications.

***Inventors' Digest*** **L5**
Boston, MA
America's #1 magazine for the independent inventor/entrepreneur who wants to learn how to bring a product to market.

**The McGraw-Hill Companies** **L9**
New York, NY
Reports on federal programs that support civilian, dual-use technologies, for industry decision-makers, government and academia interested in funding, partnering, and technology transfer opportunities.

**Rubbercraft** **L4**
Buena Park, CA

**New England Design & Manufacturing Expo**

The first major design engineering exposition in the heart of the New England high-tech corridor, NEDME will feature new products and services to help engineers meet their design, prototyping, testing, and production challenges. (Sponsored by *NASA Tech Briefs* and *Rapid Product Development* magazines)

**Advanced Microelectronics Inc.** **2811**
Nashua, NH
Electronic circuit/packaging design and manufacturing services. Specializing in prototypes, SMT, COB, MCM, hybrids, test probes, and miniature products.

**Agile Software Corporation** **2806**
San Jose, CA
Leading supplier of Windows® and Java® client/server applications for desktop-based Product Data Management (PDM), engineering change control, and supply chain management, with out-of-the-box interfaces to ERP systems.

**Algram America** **3012**
Nanuet, NY
Algram is a manufacturing company with 30 years experience in mold tool making, injection molding, vacuum forming, and assembly. Their focus is manufacturing tools for prototype or low to medium volume production for the aerospace, automotive, and medical equipment sectors.

**Armor Box Company** **3008**
Bloomfield, CT
The company offers hard-sided shipping cases for valuable equipment of any size, any shape, any interior. They feature metal-edged exteriors and padded interiors.

**Armstrong Mold** **2802**
East Syracuse, NY

**ARRK Product Development Group** **2817**
San Diego, CA
ARRK's wide range of capabilities include rapid prototyping, CAD/CAM machining, fabrication, vacupressure molding, rapid castings, pre-production injection molding, and complete model-making services.

**Belt Technologies** **2711**
Agawam, MA
Belt is a worldwide manufacturer of precision metal and composite belts used in automated assembly, inspection, and precision positioning applications.

**C2C Technologies** **2812**
Millburn, NJ

**CGI** **3006**
Minneapolis, MN
The company will showcase the CSC-1000 Inspection System, which significantly reduces development costs and processing time involved with First Article Inspection of parts with complex internal geometry.

**China Office of National Science & Technology Award** **2902 - 2914**
Beijing, China

**Clippard Instruments/ Minute Man Controls** **2715**
Cincinnati, OH

**Coherent Inc.** **2815**
Santa Clara, CA
Coherent, Inc. designs and manufactures lasers, laser diodes and laser systems for imaging, holography, inspection, material processing, metrology, data storage, and printing markets.

***Commercial News USA*** **2821**
New York, NY
The Department of Commerce's official export marketing magazine, helping U.S. companies find buyers and distributors in 150 countries worldwide.

**Craftech Industries** **3220**
Hudson, NY
High-technology plastic fasteners, pipe hangers, hinges, handles, structural hardware, tools, and shapes for chemical processing and handling, and other industries.

**Fred V. Fowler Co.** **3212**
Newton, MA
The company offers precision tools, measuring tools, gauges, inspection equipment, SPC software, and data acquisition software.

**Haptic Technologies Inc.** **2814**
Montreal, Quebec

**Harvard Thermal Inc./ Brazonics Inc.** **3222**
Harvard, MA
Harvard Thermal developed the Windows 95/NT-based general-purpose thermal modeling software, TAS (Thermal Analysis System). Brazonics is a complete source for fabricated assemblies, enclosures, and chassis.

**The Jade Corp.** **2907**
Huntingdon Valley, PA
Jade is a full-service engineering and manufacturing company. Capabilities include tooling, automated assembly machines, precision machining, and stamping, serving the electronics, automotive, medical, and communications industries.

**Jentek Sensors Inc.** **2721**
Watertown, MA

**Marchetti Design & Engineering/Baystate** **2820**
Leominster, MA
Marchetti is a leading reseller in the CAD industry, as well as an Authorized Training Center. They won the award for the Number One 1998 Eastern Regional CADKEY Dealer from Baystate Technologies.

**Massachusetts Materials Research Inc.** **2713**
West Boylston, MA
Laboratory services include metallography, chemistry, mechanical, and NDT. Consulting for industry, insurance, and legal firms.

**MCP Systems** **2803**
Fairfield, CT
MCP provides equipment and services to create multiple prototype parts from RP patterns. MCP Vacuum Casting offers speed: 6 to 8 duplicates/day; versatility: flexible, heat resistant, clear thermoplastic-like materials; and quality: void-free structures.

***NASA Tech Briefs*** **2821**
New York, NY

**NERAC Inc.** **2707**
Tolland, CT
NERAC accesses leading sci-tech sources around the globe to assist American companies in problem resolution and awareness of technological, patent, and market developments. Key are NERAC's large staff of experienced engineers and scientists.

**Océ -USA** **2703**
Waltham, MA
The company provides document management equipment and software for engineering-size drawings, including plotters, scanners, copiers, and software tools for printing and archiving digital images.

**OMEGA Shielding Products** **2905**
Cedar Grove, NJ
Will display electronic gaskets.

**Picatinny Arsenal Technology Transfer** **3002**
**Advanced Systems Concept Office**
Picatinny Arsenal, NJ

The U.S. Army ARDEC has a unique collection of technologies and excels in areas such as Material Science/Analysis, Manufacturing Processes, Virtual Reality/Simulation, Image Processing, Electromagnetics, Energetics/Pyrotechnics, and more.

**Primavera Systems Inc.** **2911**
Cambridge, MA

Primavera Systems delivers innovative software products and services to help customers successfully manage all of their projects and resources.

**Romer Inc.** **3216**
Enfield, CT

Romer manufactures and distributes the Romer portable CMM, a unique, six-axis articulated-arm CMM that reaches anywhere you can and provides accurate measurements down to 0.001".

**Sanders Design International** **2808**
Wilton, NH

The Sanders ModelMaker™ System produces precision prototypes rapidly and accurately for direct casting of parts.

**Sensor Products Inc.** **2709**
East Hanover, NJ

Sensor Products markets a variety of sensing technologies that all share the common characteristic of changing appearance (color) upon exposure to various physical phenomena. Their pressure indicating films record both pressure distribution and magnitude between contacting or impacting surfaces.

**Spacetec IMC Corp.** **2810**
Lowell, MA

Spaceball FLX 3D Motion Controllers allow users to pan, zoom, and rotate 3D models with simultaneous six degrees of freedom control.

**Stratasys Inc.** **2807**
Eden Prairie, MN

Stratasys offers the easy-to-use Genisys 3D printer that produces fast iterations of concepts early in the design cycle. It generates 3D prints in a durable polyester compound.

**Winfield Industries Inc.** **3010**
Buffalo, NY

**Z Corporation** **2809**
Somerville, MA

The company manufactures the Z402™ system, the world's fastest 3D printer. It is an affordable rapid prototyping system that builds parts of virtually unlimited geometric complexity in an office environment directly from CAD files.

SMALL BUSINESS TECH EXPO

**Small Business Tech Expo**

First annual showcase of resources and technologies to launch new products and partnerships. Find financing and investment opportunities, marketing expertise, and consulting services. (Sponsored by ABP-DBA Conference & Exposition Services)

**Advanced Fuel Research/ On-Line Technologies** **2923**
Hartford, CT

AFR provides R&D services, instrumentation and software for process monitors, engineered materials, and advanced fuels. On-Line makes advanced process control tools for the semiconductor industry.

**AstroTerra Corp.** **2931**
San Diego, CA

AstroTerra's TerraLink™ line of laser communication systems provides secure, protocol-independent, high-bandwidth, and long-range data links between sites, offering an alternative to fiber optic cable and microwave systems.

### Beam Engineering for Advanced Measurements (BEAM) Corp. 2928

Oviedo, FL

The company provides nonlinear optical technology for characterization of focused laser beams' profile and measurement of peak intensity with the aid of transparent thin layers of liquid crystals.

### Busek Co. Inc. 2936

Natick, MA

Will describe capabilities in satellite propulsion: fabricating and testing of Hall thrusters and specialty cathodes; Materials: brazing and joining services for ceramics; and ceramic MEMs and coatings.

### Clallam and Jefferson Counties Science, Technology & Manufacturing Association 3028

Port Angeles, WA

Members represent high-technology manufacturing/consulting firms. Disciplines represented include hydrodynamics, advanced graphite composite manufacturing, high-energy/explosive technologies, marine and aquatic sciences, and database management software.

### CoreTek 2929

Burlington, MA

### Environmental Technology Commercialization Center 2827

Cleveland, OH

Provides assistance to firms seeking to acquire and adapt technology developed by the U.S. Environmental Protection Agency.

### Epitaxial Technologies 2927

Baltimore, MD

### NASA Small Business Solutions Center 2826

Greenbelt, MD

Featuring displays of NASA's SBIR (Small Business Innovation Research) and STTR (Small Business Technology Transfer) program opportunities, NASA technologies developed through these programs, and a guide to other small business resources at Tech East.

### Naval Aviation Systems TEAM, Business Development Office/Naval Air Warfare Center, Aircraft Div. 3022

Patuxent River, MD

As the Navy's full-spectrum RDT&E, engineering, and fleet support center, they are the leader in the design, development, and engineering of aircraft systems; shipboard, fixed, and mobile communications; and information technology systems.

### The Patuxent Partnership 3022

Leonardtown, MD

Southern Maryland's support network for technology driven economic development offers technical assistance and specialized facilities with a focus on aviation, communications, computer science, and materials.

### PLEX LLC 2932

Brookline, MA

Will feature a novel, intense laboratory source of soft X-rays suitable for extreme ultraviolet lithography, microscopy, and materials studies.

### Sheet Dynamics Ltd. 2926

Cincinnati, OH

Dynamic test, modeling, control, and design capabilities with advanced spatio-temporal filter-based algorithms. Applications include optical space telescopes, steel and paper production, and process instrumentation.

### SRTC Business Development Department 2829

Aiken, SC

Will present the roles of vitrification, biotechnology, sensor, and remote and robotic technologies in waste treatment and environmental remediation.

### Structured Materials Industries/Nanopowder Enterprises Inc. 2934

Piscataway, NJ

Structured Materials Industries manufactures oxide chemical vapor deposition equipment and oxide thin films: ferroelectric and dielectric (memory/pyroelectric detector), superconductor, giant-magneto-resistance, phosphor and transparent/conductive (display), among other oxide films.

Nanopowder Enterprises manufactures non-agglomerated, high purity nanopowders, with narrow size distribution, nanograined films and production equipment; special focus nanopowders for CMP, cosmetics, sensors, heat transfer, conducting, etc.

### Synkinetics Inc. 2831

Lowell, MA

Precision motion control products for military and commercial applications. Products include a lightweight antenna gimbal assembly and compact rotary table, featuring the patented Syndrive technology.

### Unigraphics Solutions 3026

Waltham, MA

Unigraphics will demonstrate Solid Edge, a parametric feature-based solid modeling product, and Unigraphics products, offering a complete mechanical CAD product line.

### UTRON Inc. 2937

Manassas, VA

The company will display high-velocity gun technology, thermal spray technology, wire arc technology, and dynamic compaction technology.


**To register for Tech East exhibits, see pages 102-103. For courses, tutorials, and all other information about this event, including the most current list of exhibitors, visit www.techeast.net.**

# Augmented Active-Pixel Sensors Would Compute Centers of Mass

**These sensors could function in either center-of-mass or normal image-readout modes.**

*NASA's Jet Propulsion Laboratory, Pasadena, California*

Circuits to generate analog or digital representations of the coordinates of the centers of mass of images would be added to imaging photodetector arrays of the active-pixel-sensor (APS) type, according to a proposal. "Centers of mass" as used here is something of a misnomer of historic origin; a more precise term would be "centers of illumination," or, the case of nonlinear or unequal photodetector responses, "centers of response." Regardless of which term one uses, the significance of the proposal is that it would enable APS units to locate and/or track still or moving images representing objects in various states of rest or motion.

For a given APS, the additional circuitry for computing the "center of mass" (COM) would be installed at the periphery of the pre-existing circuitry. The additional circuitry would thus not degrade the original optical properties or interfere with the original electronic functions of the APS. The APS could be operated in its normal image-readout mode, or optionally, it could be operated with the additional circuitry in a COM mode.

The objective in the COM mode is to generate numbers or analog signals representative of horizontal and vertical pixel coordinates of the center of illumination. In mathematical terms, what one seeks is the brightness-weighted (or response-to-brightness-weighted) average coordinates given by

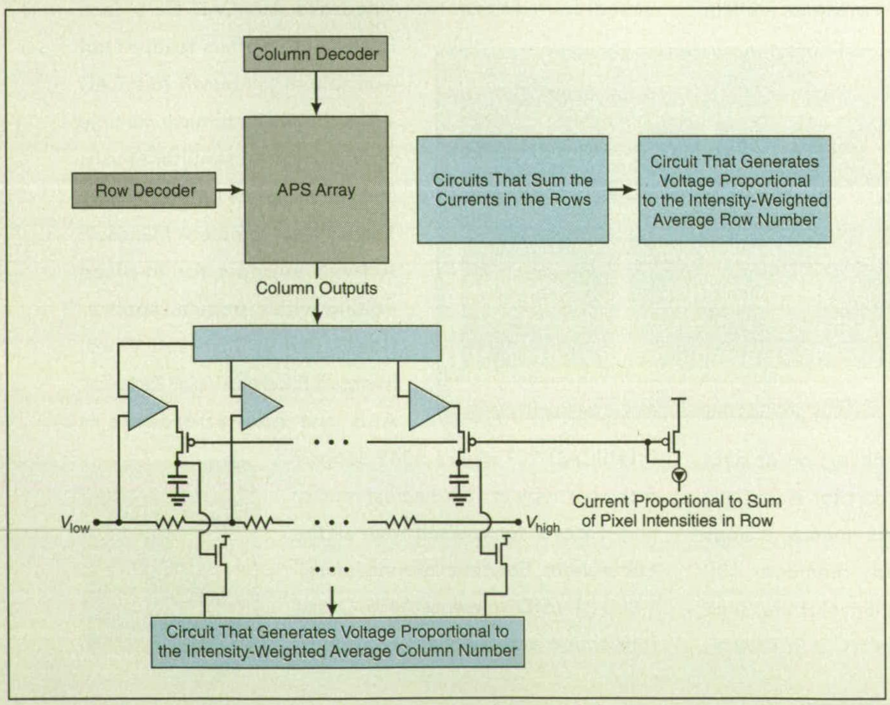
$$\bar{x} = \frac{\left[\sum_{i=1}^{M}\sum_{j=1}^{N} x_j I_{ij}\right]}{\left[\sum_{i=1}^{M}\sum_{j=1}^{N} I_{ij}\right]}$$

and

$$\bar{y} = \frac{\left[\sum_{i=1}^{M}\sum_{j=1}^{N} y_j I_{ij}\right]}{\left[\sum_{i=1}^{M}\sum_{j=1}^{N} I_{ij}\right]}$$

where $\bar{x}$ and $\bar{y}$ are the horizontal and vertical COM coordinates, respectively; $x_j$ is the horizontal coordinate of the $j$th column; $y_i$ is the vertical coordinate of the $i$th row; $I_{ij}$ is the level of illumination (or response to illumination) in the pixel in the $i$th row and $j$th column; and $M$ and $N$ are the numbers of rows and columns, respectively.

The COM operation could be implemented by use of analog peripheral circuitry like that shown in simplified form in the figure. Alternatively, the COM operation could be implemented by use of digital peripheral circuitry: Taking one row at a time, the intensity-of-illumination signal from the pixel in each column would be sent to one of the input terminals of a multiplying digital-to-analog converter (MDAC). The column address or other number representative of the horizontal coordinate of the column would be sent to the other input terminal of the MDAC. The product outputs of all the MDACs for all the columns would be summed, then divided by the sum of intensity signals of the columns to obtain the horizontal COM coordinate of the row. Then $\bar{x}$ would be computed as an intensity-weighted average of the horizontal COM coordinates of all the rows, while $\bar{y}$ = would be computed as an intensity-weighted average of the numerical addresses (or other numbers representative of the vertical coordinates) of the rows.




**Peripheral Circuits** would perform COM operations when needed. At other times, the APS array would operate in a normal image-readout mode.

*This work was done by Orly Yadid-Pecht, Brad Minch, Bedabrata Pain, and Eric Fossum of Caltech for* **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Circuits category.*

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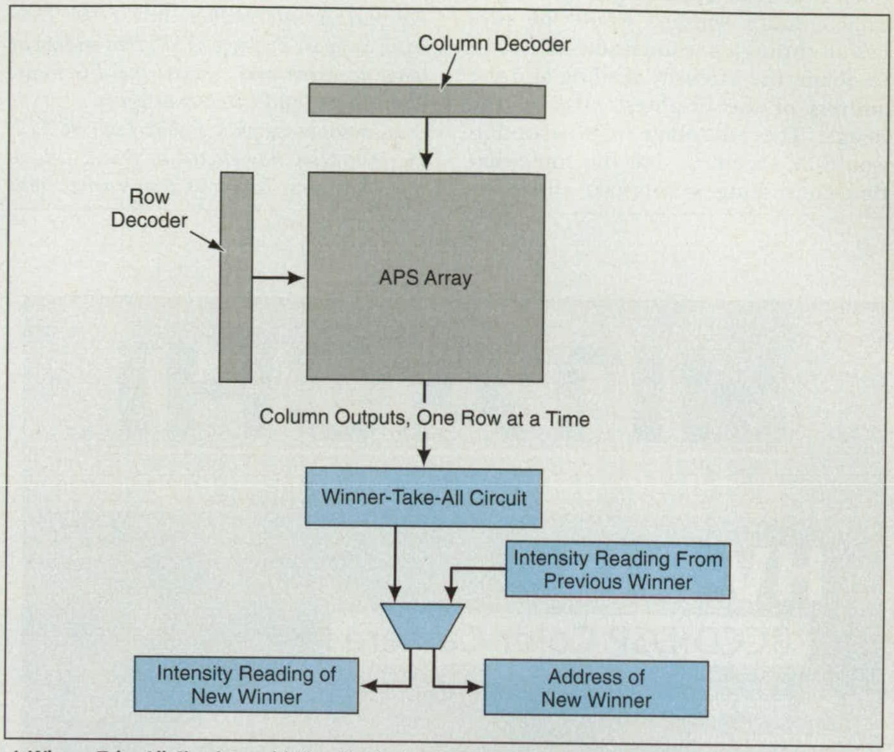
## Active-Pixel Sensors With "Winner-Take-All" Mode

### These sensors could function in either brightest-pixel or normal image-readout modes.

*NASA's Jet Propulsion Laboratory, Pasadena, California*

Circuits to generate the intensity reading and the coordinates of the brightest pixel in each image would be added to imaging photodetector arrays of the active-pixel-sensor (APS) type, according to a proposal. For a given APS, the additional circuitry for locating the brightest pixel would be installed at the periphery of the basic APS circuit. The additional circuitry would thus not degrade the original optical properties or interfere with the original electronic functions of the APS. The APS could be operated in its normal image-readout mode or, optionally, it could be operated with the additional circuitry in the brightest-pixel mode. Potential applications could include star tracking or fast tracking of a moving laser-beam spot in laser communication system.




A **Winner-Take-All Circuit** would identify the brightest pixel in each row in turn. This pixel would be compared with the brightest pixel found in the preceding rows.

The brightest-pixel mode would be a winner-take-all mode. The pixel intensities would be read out row by row as in ordinary imaging, but unlike in ordinary imaging, the column intensity values for each row would be processed through a winner-take-all circuit (see figure) that would select the brightest pixel in the row. The intensity reading of the brightest pixel in the row most recently read out would be compared with the previous winner; that is, with the stored intensity reading of the brightest pixel (if any) found in all previous rows. If the greatest intensity reading from the most recent row were greater than the stored intensity reading, then the pixel with this reading would become the new winner, and its intensity reading and coordinates would be stored. Once the intensity readings from all the rows in the APS had been processed in this way, the final winner would be the brightest pixel in the image.

There are several design options for the winner-take-all circuit and the overall mode of operation. In one option, the winner-take-all function would be implemented by a fast current- or voltage-mode analog circuit. In another option a hybrid analog/digital circuit would generate and compare an increasing voltage (ramp voltage waveform) with intensity-reading voltages for all the columns and would latch the address and intensity value for the column that most recently matched the ramp voltage.

In yet another option, each column pixel in the row read out most recently

would be compared with the previous winning pixel in that column and would, if appropriate be declared the new winner. Once the last row had been thus read out and processed, the final column winners would be processed through a winner-take-all circuit to obtain the intensity reading and the address of the brightest pixel in the image. The advantage of this option would be speed, in that the somewhat time-consuming winner-take-all operation would be performed only once per frame period.

*This work was done by Orly Yadid-Pecht, Eric Fossum, and Carver Mead of Caltech for* **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Circuits category.*

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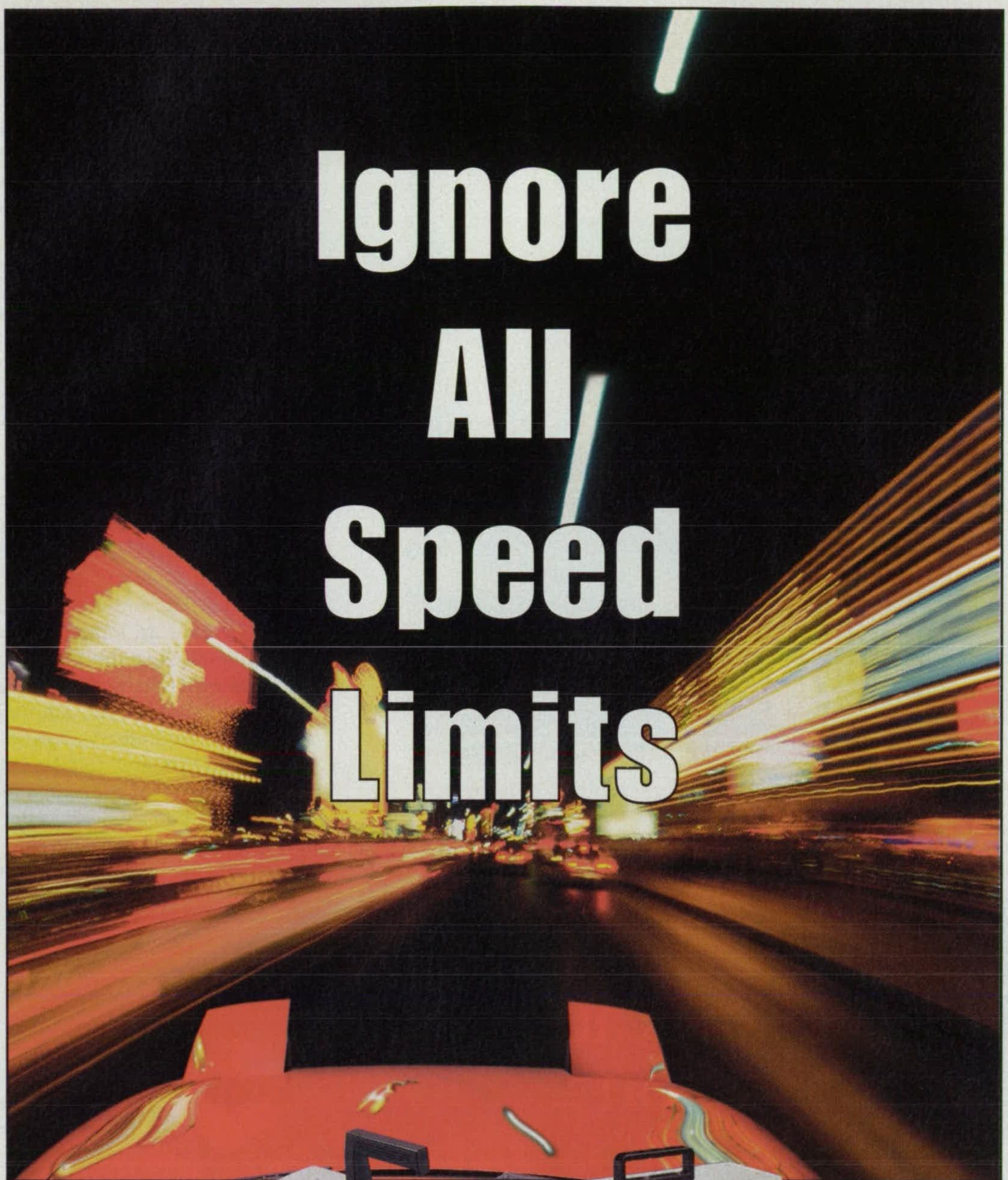
# Active-Pixel-Sensor Digital Camera on a Single Chip

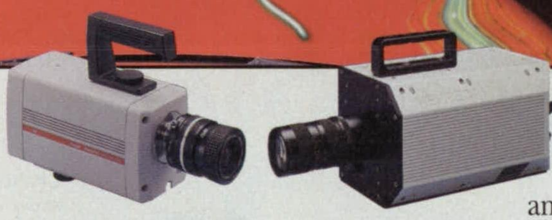
### The entire camera, exclusive of the optics, is only 1 cm$^3$ (0.06 in.$^3$).

*NASA's Jet Propulsion Laboratory, Pasadena, California*

The figure shows a complementary metal oxide/semiconductor (CMOS) integrated circuit that contains all of the electronic circuitry of a programmable active-pixel-sensor digital camera. Heretofore, digital cameras have been assembled from charge-coupled-device (CCD) chips, separate analog-to-digital converters, and separate units that perform timing, control, and interface functions; each unit adds to the size, cost, and power consumption of a camera. The present single-chip camera is a prototype developed for many applications within the space program. It also meets the demands of a large potential market for compact, low-power-consumption, and (eventually) inexpensive portable digital cameras. The chip has been packaged as a low-power camera occupying only 1 cm$^3$ (0.06 in.$^3$), exclusive of optics, with an all-digital 5-wire serial interface. The chip is also being incorporated, along with a wireless interface unit, into a battery-operated camera with a volume of less than 32 cm$^3$ (2 in.$^3$).

Included on the chip are analog-to-digital converters (ADCs) and full timing, control, and interface circuitry. All analog reference voltages for imaging and digitization are generated by programmable digital-to-analog converters (DACs) that are also included on the chip. Thus, the camera contains a complete digital interface. Through a single digital input pin, the chip can be programmed to perform a variety of imaging operations and/or to establish the required interface configuration; this capability facilitates integration with a variety of external digital systems.



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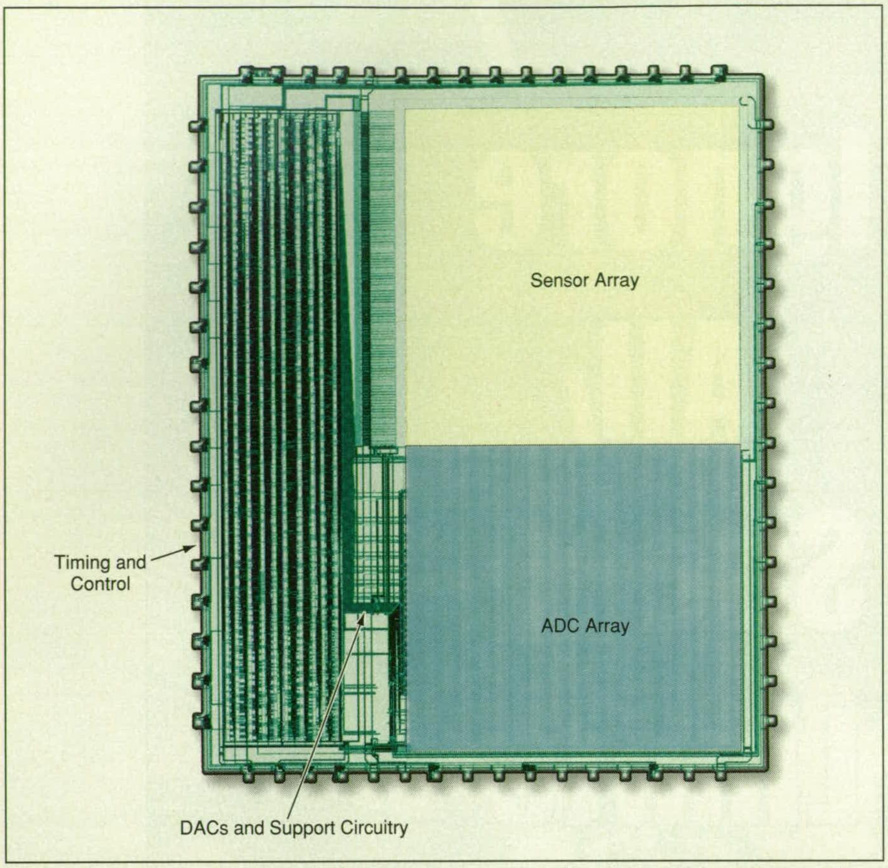
**For More Information Circle No. 511**




**All the Electronic Circuitry of a Digital Camera** fits in a rectangular area of 9.3 by 11.2 mm and consumes only milliwatts of power.

The image-sensor portion of the chip is a 256 × 256 array of photogate active pixel detector circuits, with a 20.4-μm pixel pitch and a 21-percent fill factor. Each pixel includes a source follower for coupling the pixel output to a column bus. Next to the sensor array is the array of ADCs, of which there are 256 in a column-parallel arrangement. Each ADC uses a successive approximation algorithm with internal correlated double-sampling and offset-correction circuits to reduce noise, designed to yield an output with 10 bits of resolution. To decrease power consumption while an image is not being acquired, the chip has a low-power (40-μW) idle mode, in which the DACs, pixel source followers, and ADCs are disabled.

The chip can be programmed in order to set the desired exposure time and to operate in any of a number of imaging modes. The amount of data and power required for an image may be reduced by programming the chip to use a smaller window contained within the 256 × 256 array and by subsampling the pixels within the desired window. Although designed primarily to take still pictures, the chip can also be programmed to acquire images continuously. After acquiring a digital still image, the chip automatically enters the low-power idle mode.

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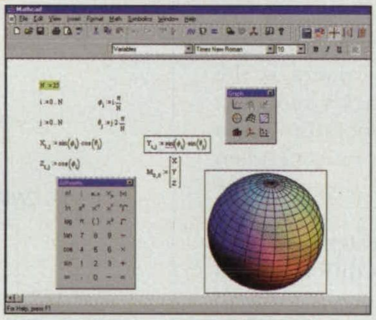

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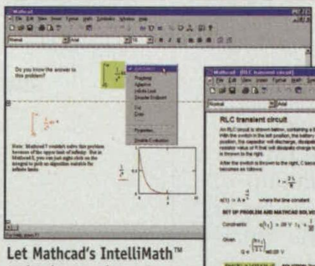

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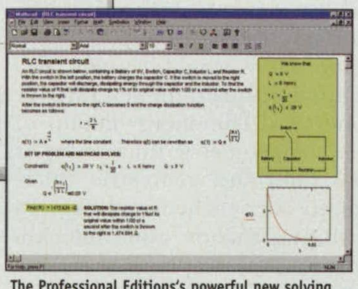

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The chip can be programmed to produce serial or parallel data output in a variety of formats. It can be made to implement full- or half-duplex protocols and to generate vertical and horizontal frame-synchronizing signals. It can accommodate a variety of input and output data rates and internal clock rates; it can even operate with separate input command and output data rates or receive asynchronous input command data at particular bit rates with no input clock. This flexibility is achieved by use of separate programmable clocks, derived internally from the input clock, to control various operations on the chip. The chip can support frame rates up to 14 Hz with serial output or 60 Hz with parallel output. During full operation with serial output, the total power consumed by the chip is about 20 mW.

*This work was done by Timothy Shaw, Bedabrata Pain, Brita Olson, Robert Nixon, Eric Fossum, Roger Panicacci, and Barmak Mansoorian of Caltech for* **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP) free on-line at **www.nasatech.com** under the Electronic Components and Circuits category, or contact Bedabrata Pain at (818) 354-8765.*

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# Optimized Two-Wavelength Focal-Plane Arrays of QWIPs

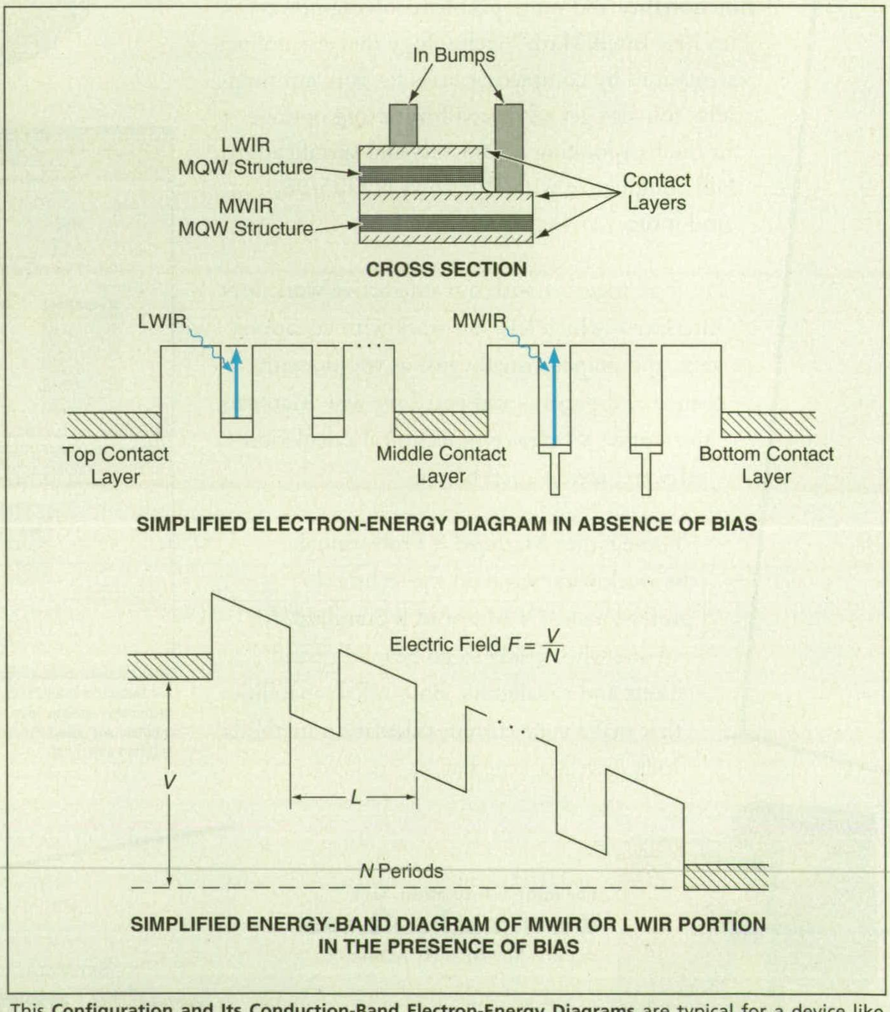
## Only one bias voltage would be needed for readout at both wavelengths.

*NASA's Jet Propulsion Laboratory, Pasadena, California*

A concept for optimizing the designs of two-wavelength GaAs-based quantum-well infrared photodetectors (QWIPs) could make it practical to use focal-plane arrays of QWIPs as image sensors in two-wavelength infrared cameras. Potential applications for such cameras include surveillance, tracking of military targets, night vision, and thermal mapping. One important advantage of a two-wavelength over a one-wavelength camera is the possibility of using Planck's radiation law to calculate the temperature of an imaged object from the ratio between the brightnesses of the object at the two wavelengths.

Concepts for using focal-plane arrays of GaAs-based QWIPs in different configurations as two-wavelength infrared image sensors have been described in previous articles in *NASA Tech Briefs*. The present concept applies to a configuration in which each pixel in a focal-plane array would contain two stacked multiple-quantum-well (MQW) photodetectors. The energy depths of the wells, the geometric thicknesses of the wells, and the geometric thicknesses of the barriers between the wells in one MQW structure would be chosen to obtain peak response in the desired long-wavelength infrared (LWIR) band; the corresponding parameters for the other MQW structure would be chosen to obtain peak response in the desired medium-wavelength infrared (MWIR) band (see figure). Both MQW structures would be biased and read out simultaneously, but independently of each other, through separate indium bump contacts connected to a readout multiplexer.

Research on previous designs based on this configuration has revealed two problems that until now have made it impractical to make a two-wavelength infrared camera. The first problem is that for simultaneous detection two-QWIP stack in each pixel must be supplied with two different bias potentials, which can-




This **Configuration and Its Conduction-Band Electron-Energy Diagrams** are typical for a device like that described in the text. The device would be grown by molecular-beam epitaxy onto a semi-insulating GaAs substrate. The contact layers would be made of heavily doped GaAs. Indium bumps would serve as contacts to external circuitry.

**For More Information Circle No. 507**

not be obtained from any currently available readout multiplexers. The second problem is that in voltage-tunable design a high bias potential (>8 V) must be supplied to the LWIR QWIP to switch on LWIR detection.

The present concept would make it possible to operate the QWIPs with equal and lower bias potentials. The QWIPs designed according to this concept would be at least as responsive as are those of older designs that require higher and unequal bias potentials. The concept involves the following reasoning: The need for different and higher bias voltages in older designs arises, in part, from fundamental physical mechanisms that make it necessary to use larger bias electric fields to detect photons of shorter wavelengths. One could obtain a given bias electric field at a lower bias potential by applying that potential across a lesser thickness of material; that is, across fewer quantum-well periods. For fundamental physical reasons, it turns out that the responsivity of an MQW device is independent of the number of MQW periods (provided that the electric field remains the same), so that one has some design flexibility to decrease the number of MQW periods.

The relevant design parameters must satisfy the following equations:

$$F_L = V_L/N_L L_L \text{ and } F_M = V_M/N_M L_M;$$

where $F_L$ and $F_M$ are the electric field needed for detection of LWIR and MWIR photons, respectively; $V_L$ and $V_M$ are the bias potential applied to the LWIR and MWIR structures, respectively; $N_L$ and $N_M$ are the number of spatial periods in the LWIR and MWIR MQW structures, respectively; and $L_L$ and $L_M$ are the depths of a quantum-well period of the LWIR and an MWIR MQW structures, respectively. Heretofore, one would typically choose $L_L = L_M$ and $N_L = N_M$, and choose two different bias potentials to obtain the required $F_L$ and $F_M$. One can still choose $L_L = L_M$ while choosing different values of $N_L$ and $N_M$ to make it possible to use $V_L = V_M$ to obtain the required $F_L$ and $F_M$. The required values of $N_L$ and $N_M$ would then be related by

$$F_L N_L = F_M N_M.$$

To obtain reasonably high reponsivity from each stack, $F_M > F_L$ is required. Thus, the obvious choice would be $N_L > N_M$. It is also worth noting that the total number of periods in the structure ($N_L + N_M$) is limited by the molecular-beam-epitaxy (MBE) growth time because it tends to increase the number of defects with the increasing growth time. Therefore, one has to increase $N_L$ and decrease $N_M$ from their values being equal. Although, this choice would result in a decrease in LWIR noise current and increase in MWIR noise current, the noise current of the LWIR QWIP is still higher than that of the MWIR QWIP. This is because dark current of the LWIR QWIP is few orders larger than that of MWIR QWIP. Therefore, overall performance of the two-wavelength QWIP will be enhanced.

*This work was done by Sumith Bandara, Sarath Gunapala, and John K. Liu of Caltech for* **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Circuits category.*

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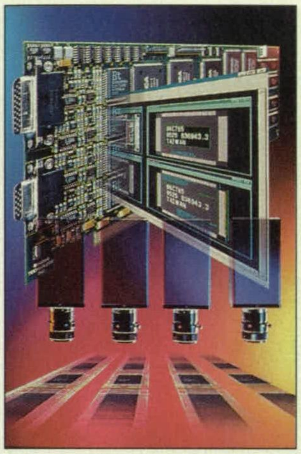
# Special Coverage: Sensors/Imaging

SICK Opto-Electronic, Bloomington, MN, offers the KT 10 **color contrast sensor** that features three LEDs — red, blue, and green. The sensor "looks" at the contrast it is required to sense, and selects the proper light source. It then sets its switching threshold halfway between the background and the mark. Manual operator adjustment is not necessary. If registration colors change, the operator presses the teach-in button, and the sensor will repeat the steps for the new colors and make adjustments.

The sensor sees only a portion of a small mark in the light spot, and web fluctuation greater than ±3 mm. It can read up to 25,000 registration marks per second. If the PLC cannot process the readings quickly enough, the sensor can be put into Run-Delay mode and the output signal will expand to 20 ms.

**For More Information Circle No. 712**



The IC-ASYNC single **machine vision board** from Imaging Technology, Bedford, MA, includes four independent, asynchronous frame grabbers on one PCI bus card. The board can acquire up to four camera inputs asynchronously, and can process high-speed applications such as multi-point inspection operations and semiconductor/electronics manufacturing.

A bus master controller monitors images being acquired into each of the four frame buffers, and transfers the video data to the host automatically. Maximum total throughput from camera to frame grabber is achieved at 80 MB/second. The board can interface to multiple cameras, and digitizes up to four channels of 8-bit data from RS-170, CCIR, or progressive scan cameras at up to 20 MHz per channel.

**For More Information Circle No. 715**

Kistler Instrument Corp., Amherst, NY, has introduced the 8770A5 and 8770A50 **impedance-head sensors** that generate acceleration and force data simultaneously. The A5 provides acceleration and force ranges from ±5 g to ±5 lb; the A50 from ±50 g to ±50 lb. Both outputs are phase-matched to within 2 degrees. Acceleration and force sensitivities are unaffected by mounting torque or mass loading effects.

A piezoelectric sensing element optimizes performance of the quartz/ceramic crystals. Acceleration frequency response is from 1 Hz to 4 kHz. Integrated Piezotron® electronics provide low impedance, voltage mode outputs. The sensors have hermetically sealed titanium enclosures.

**For More Information Circle No. 716**

Ono Sokki Technology, Addison, IL, offers the GS-1630 **linear gage sensor** for measuring dimensions, thickness, curvature, eccentricity, height, depth, flatness, variation, runout, roundness, distortion, deflection, load, and pressure. It uses linear glass scale technology and measures to 0.00005" throughout a 1.2" range.

The sensor features a dust-proof and splash-proof structure that conforms to protection class IP-64 for harsh environments. It is capable of use beyond five million strokes. Automated measurement is possible by attaching an optional air lifter. The sensor comes with a 6-foot signal cable that can be connected to remote displays with various outputs.

**For More Information Circle No. 714**

The Model QMT42 fixed-field **photoelectric sensors** from Banner Engineering Corp., Minneapolis, MN, are available in three ranges: 20" (500 mm), 39" (1000 mm), and 79" (2000 mm). The diffuse (proximity) photoelectric sensors utilize optical triangulation to sense the target. They are able to sense flat black objects at exact distances while ignoring reflective backgrounds inches beyond the cutoff point. They sense both dark and light objects equally; high-gain circuitry allows black plastic or recycled wooden pallets to be detected.

The 10 to 30V dc sensors have two complementary outputs — one normally open and one normally closed — offering a response time of 1 millisecond. They have a die-cast alloy housing finished in black acrylic polyurethane, acrylic lenses, and 6.5' or 30' attached cable. The sensors operate in temperatures from -4 to 131°F.

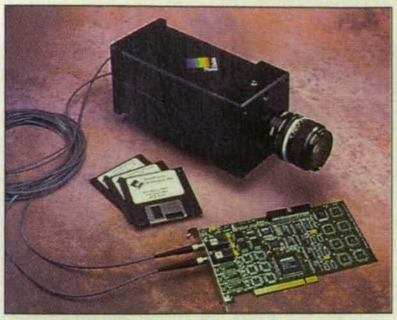
**For More Information Circle No. 713**


PPT Vision, Eden Prairie, MN, has announced the Passport® DSL™ **digital machine vision system** that utilizes a two-way digital serial communications network for real-time simultaneous image acquisition and data transfer. Up to 16 digital cameras can be connected to the processor over long distances using a twisted-pair cable. Bi-directional communication speeds of 330 Mbps can be achieved.

The system can accommodate a variety of camera types with different operating characteristics; both digital and analog at varying resolutions. The DSL PCI-based host board and FlashFind™ pattern recognition hardware accelerator combine to capture and process inspection data. Windows-based Vision Program Manager software uses a set of graphic programming tools that are dragged and dropped into a flowchart representing the actual inspection process.

**For More Information Circle No. 723**

# Special Coverage: Sensors/Imaging



The BioXight™ series of **CCD cameras** from PixelVision, Beaverton, OR, is designed for physical- and life-science applications. The modular 14-bit cameras are available with resolutions to 4096 × 4096 pixels, and attain data collection up to 80 Mbps. The cameras incorporate proprietary architecture and are equipped with two-stage thermoelectric coolers. Each camera has a multiple-input PCI computer interface that allows data transmission to several kilometers via fiber-optic cable.

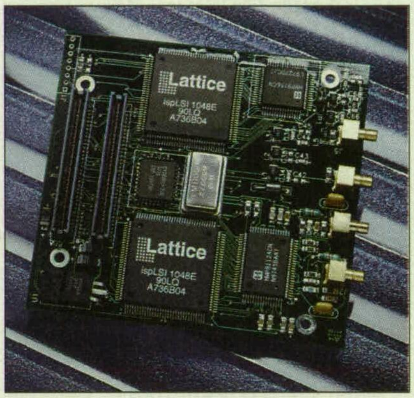
The cameras are available with Windows 95/98/NT-based PixelView™ image processing software. Optional binning allows users to operate the cameras at faster frame rates. Other options include multi-pinned phase clocking for enhanced dark-current suppression and back-illuminated operation.

**For More Information Circle No. 719**

Scientific Technologies, Fremont, CA, has introduced the DF 7000 Series **ultrasonic sensor** for continuous measurement of solid or liquid levels, and for non-contact measurement of either range or size of a detected object. The sensors have a range to 20' and utilize a microprocessor-based design. Output is converted into both a user-selectable analog signal and an RS-232/RS-485 signal.

The sensors come with a Windows or DOS communication utility program, and can be configured with a remote handheld programmer. They can be used with panel-meter displays, and feature standard continuous voltage and milliampere outputs. Options include an RF modem for remote communication, MP3000 analog controller, and the OPT-1003 mounting bracket.

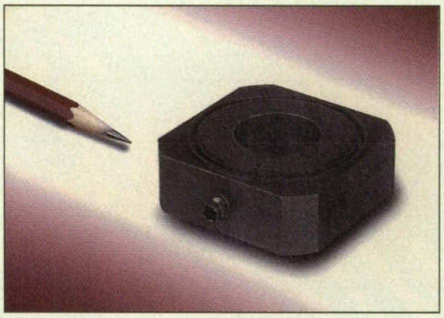
**For More Information Circle No. 717**




BittWare Research Systems, Concord, NH, offers the bitsi-VIDEO **video image processing mezzanine** that interfaces NTSC/PAL video signals with SHARC processors in real time. The system captures and displays composite/S-Video signals for real-time image processing applications requiring rapid scanning.

The mezzanine mounts to SHARC-based host boards and uses an integrated interface to transmit video signals to the SHARC processor on the host board. Using square pixel or CCIR601 data formatting, the mezzanine encodes from and decodes to 8-bit YCrCb format digital data.

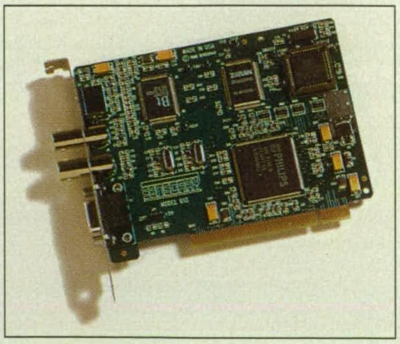
**For More Information Circle No. 722**



The Model 260A03 ICP® 3-Component **force sensor** from PCB Piezotronics, Depew, NY, simultaneously measures dynamic or quasi-state force in three orthogonal directions. The sensor incorporates built-in microelectronics to convert the high-impedance charge output from the quartz element to a low-impedance voltage output.

The sensor is structured with three preloaded quartz elements. Operating range is 10,000 lbs. in the z-axis. It provides a voltage output of 0.25 mV/lb in the z-axis, and 1.25 mV/lb in the x- and y-axes. Other features include hermetic, stainless steel construction. The sensor can be used in monitoring, modal analysis, biomechanics, and impact testing applications.

**For More Information Circle No. 721**



Sensoray, Tigard, OR, has introduced the Model 613 PCI bus **frame grabber** for industrial image capture applications. The system captures analog color and monochrome images in real time and converts to digital format for computerized image processing and display. Camera images may be compressed in real time using on-board MJPEG hardware.

Up to three cameras, two with composite video and one with S-video output, may be connected to the board to receive input from NTSC, RS-70, PAL, SECAM, and CCIR. Four input and four output lines are available to control camera focus, pan, tilt, and triggering circuits. The board supports various digital formats, including RGB24 and Y8, that are directly compatible with Windows bit maps.

**For More Information Circle No. 720**

Turck, Minneapolis, MN, offers picoprox® miniature inductive **proximity sensors** that fit into confined spaces near or inside machinery for positioning control, inspection, small parts placement, robotic grippers, and counting applications. The sensors are self-contained DC units that can switch a 100mA load within 4-mm, 5-mm, 6.5-mm, and 8-mm diameter housings.

Sensing ranges are relative to size, up to 4-mm range in an 8-mm diameter package. An integral four-way LED indicator provides operational information. The eurofast® and picofast® connectors enable disconnect or replacement without rewiring. Short-circuit, overload, and reverse-polarity protection are standard.

**For More Information Circle No. 718**

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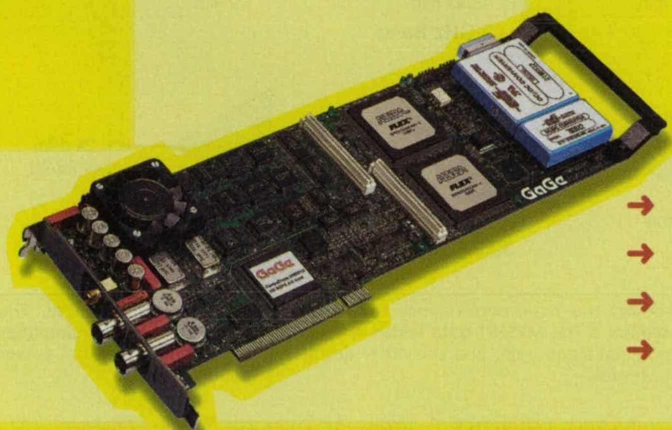

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# Monolithic GaAs FET Power Amplifiers for $K_a$ Band

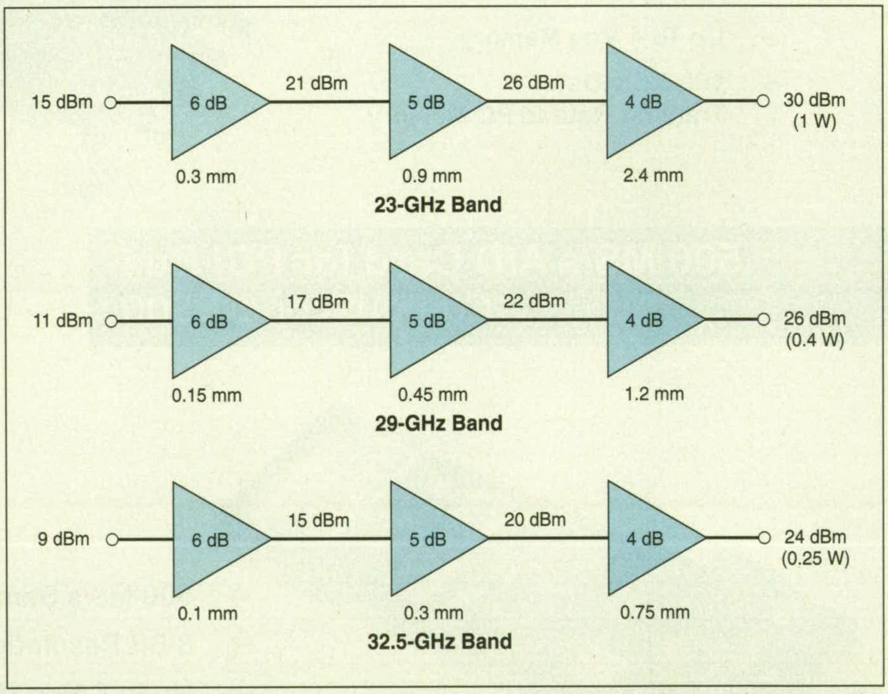
## These are prototypes of amplifiers for advanced communication systems.

*Lewis Research Center, Cleveland, Ohio*

A program to demonstrate the feasibility of GaAs-based $K_a$-band power amplifiers has generated a number of technological advances. The goals of the program included (1) capability of amplifier operation at center frequencies of 23, 29, and 32.5 GHz; (2) bandwidth of 5 percent at each center frequency; and (3) gains and output power levels as specified in the table. Each amplifier was to contain three metal/semiconductor field-effect transistor (MESFET) stages, the MESFET gate width in each stage being larger than that of the preceding stage (see figure). During the program, one- and two-stage amplifier submodules with various input and output network configurations were also constructed and tested to characterize the input, output, and interstage-matching electrical characteristics of the networks.

| | Frequency, GHz | Gain, dB | Power, W | Efficiency, Percent |
|---|---|---|---|---|
| Initial Program | 23.0<br>29.0<br>32.5 | 15<br>15<br>15 | 1.00<br>0.40<br>0.25 | 25<br>20<br>20 |
| Modification 1 | 32.5 | 20 | 0.10 | 35 |
| Modification 2 | 32.5<br>32.5 | 15<br>10 | 0.25<br>1.00 | ≥50<br>≥35 |

The **Parameters in the Table** represent the amplifier-performance goals at various stages of the program.




These **Block Diagrams** depict the basic performance requirements for the amplifier stages. The dimension below each symbol is the MESFET gate width, the decibel number inside each amplifier symbol represents the nominal stage gain, and the other decibel numbers denote nominal power levels at the indicated locations.

At the beginning of the program, odd-shaped vapor-phase epitaxial (VPE) MESFET wafers were used. A breakthrough in power and efficiency was achieved by use of highly doped (doping density $8 \times 10^{17}$ $cm^{-3}$) MESFET material grown by molecular-beam epitaxy. At an operating frequency of 34 GHz, a monolithic amplifier that had gate widths of 50, 100, and 250 μm exhibited a gain of 16 dB, yielding an output power of 112 mW with 21.6-percent efficiency.

The next breakthrough came with the use of heterostructures grown by MBE (AlGaAs/InGaAs wherein the InGaAs was highly doped). These heterostructures made it possible to achieve high power density with high efficiency. For example, a single-stage monolithic microwave integrated circuit (MMIC) amplifier containing a MESFET with gate width of 100 μm exhibited an efficiency of 40 percent at 32.5 GHz. The corresponding three-stage amplifier (with gate widths of 50, 100, and 250 μm) put out 180 mW at a gain of 23 dB and an efficiency of 30.3 percent.

The next breakthrough was achieved with 3-in. (7.6-cm) pseudomorphic high-electron-mobility transistor (PHEMT) wafers, each incorporating an etch-stop layer for the gate recess (made by reactive-ion etching). Again, state-of-the-art performances were achieved: efficiency of 40 percent with output power of 235 mW and gain of 20.7 dB. A single-stage 2 × 600-μm chip generated an output power of 794 mW with a gain of 5 dB and a power-added efficiency of 38.2 percent.

*This work was done by Edward J. Haugland of* **Lewis Research Center** *and Paul Saunier and Hua Quen Tserng of Texas Instruments, Inc. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Circuits category.*

*Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7–3, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16626.*

# Micromachined Magnetostatic Switches

## There are numerous potential applications in sensing and control.

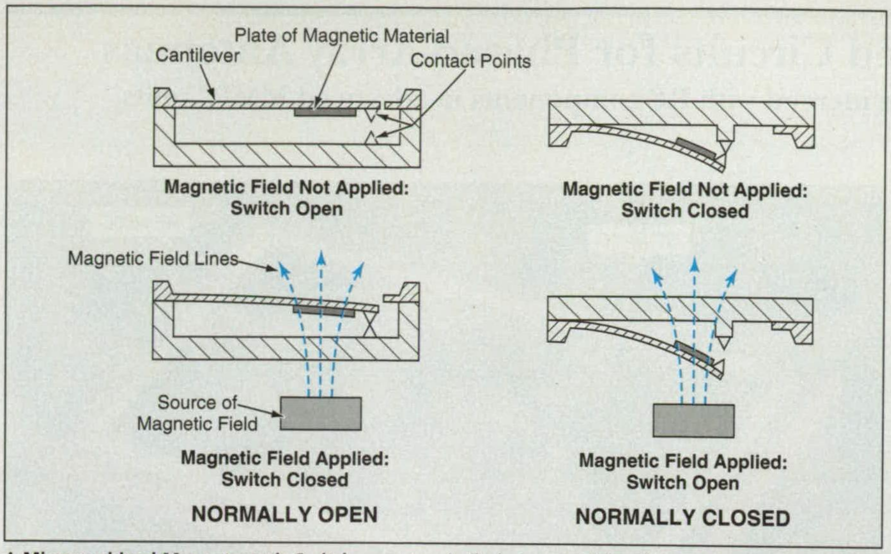
*NASA's Jet Propulsion Laboratory, Pasadena, California*

Magnetostatic switches — switches that open or close in response to magnetic fields — are being developed and fabricated using micromachining (MEMS) technology. These switches operate similarly to traditional magnetic reed switches, but can be made much smaller. While capable of serving as direct replacements for traditional relays and switches, these MEMS devices open up many new application areas. For example, the magnetostatic switches are being used as compact, lightweight, energy-efficient replacements for bulky electronic commutation circuitry in brushless dc electric motors. For another example, an array of MEMS switches, each of which opens or closes at a different magnetic-field strength, could serve as a rotary encoder or magnetometer.

The components of a basic micromachined magnetostatic switch are (1) a cantilever-beam spring and supporting structure made of an electrically insulating material, (2) a small plate of magnetic material attached to the cantilever, and (3) contact points and electrical leads made of an electrically conductive material. The switch can be normally open or normally closed. The basic principle of operation is illustrated in the figure. In the presence of a suitably oriented magnetic field, the magnetic force on the soft magnetic plate either bends the cantilever to bring the contacts together (in the case of normally open) or else pulls the contacts apart (in the case of normally closed). When the magnetic field exceeds a threshold value, the switch becomes closed (in the case of normally open) or open (in the case of normally closed).

The large variety of potential designs and materials precludes a complete description in this article. In a typical case, the electrically insulating structural material is oxidized single-crystal silicon. Silicon is chosen both for its attractive mechanical properties and for the potential of integrating the MEMS switches with electronic components in a single monolithic process. A micromachined magnetostatic switch or an array of such switches can be produced on a single sil-




A **Micromachined Magnetostatic Switch** operates similarly to a traditional magnetic reed switch, but can be made much smaller.

icon wafer or else assembled from two or more substrates. Electromagnet coils can be integrated on the substrate along with the switches to form fully integrated electromagnetic relays.

The soft magnetic material chosen for the prototype micromachined magnetostatic switches is the alloy $Ni_{80}Fe_{20}$ (permalloy). High-quality specimens of this alloy exhibit relative permeability as large as 5,000; this is desirable because the higher the permeability the more sensitive the switch. High-quality films of permalloy can be formed by electroplating.

Gold has been chosen as the electrical-contact material for the prototype switches. Gold can be deposited easily, resists oxidation, and exhibits contact resistances.

Experiments on the prototype switches have yielded some approximate performance figures. Switch contact forces >5 mN, and contact resistances <35 mΩ have been achieved at applied magnetic flux densities of about 0.25 Tesla. Switch lifetimes with hot closures (current flowing immediately upon closure) are in the range of $10^5$ to $10^6$ cycles at high currents (0.45 A). At low currents (1 mA), switch lifetimes have exceeded $5 \times 10^8$ cycles, with no failures observed.

*This work was done by Yu-Chong Tai and John A. Wright of Caltech for* **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Circuits category.*

*In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to*

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*Refer to NPO-20415, volume and number of this* NASA Tech Briefs *issue, and the page number.*

# System-Level Integrated Circuits for Phased-Array Antennas

## Support and interface circuits are merged with RF components in advanced MMIC units.

*Lewis Research Center, Cleveland, Ohio*

Modules of electronic circuitry that perform the amplitude- and phase-control and the status-monitoring functions for eight-element (2 × 4) subarrays of K-band phased-array antennas have been developed as prototype building blocks for future phased-array antennas. These modules are characterized as, among other things, system-level integrated circuits (SLICs) because they reach a new level of functionality, previously achieved only by use of larger, heavier systems. This functionality is achieved through sophisticated design that incorporates monolithic microwave integrated circuits (MMICs) and other components and involves an unprecedented degree of integration of these components with regard, not only for electrical performance, but also for considerations as diverse as temperature control, size, weight, mass-producibility, reliability, cost, complexity of interconnections, and compatibility with other electronic equipment.

Exploiting recent advances in MMICs, photonics, and packaging, each SLIC module contains optoelectronic and electronic support and interface components and circuits integrated directly with radio-frequency (RF) components and circuits. Each SLIC module (see Figure 1) comprises a tilelike array of MMIC submodules plus supporting control and signal-distribution elements. All of these components are integrated into a single thin, lightweight package by use of the microwave high-density interconnect (MHDI) process, which is the enabling process for making tilelike phased arrays with the desired level of calibration and control.

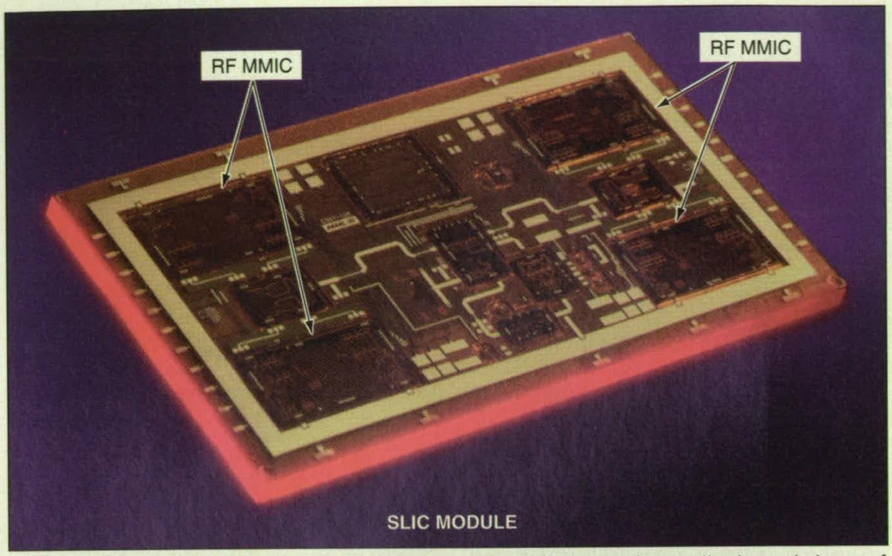



Figure 1. **One Compact Package** contains all the circuitry needed to set the amplitudes and phases of RF signals in eight antenna elements at commanded values.

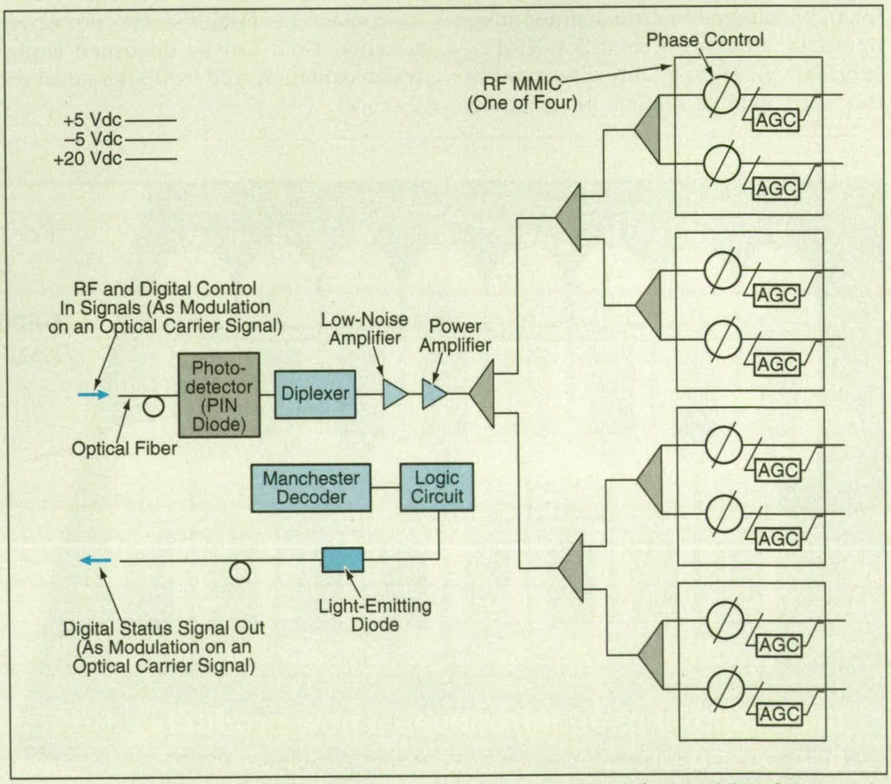



Figure 2. This **Simplified Block Diagram** represents the major functions of submodules of the module shown in Figure 1.

Among the submodules in each SLIC module (see Figure 2) are four highly integrated dual-channel RF MMICs, each of which contains two phase shifters that operate under 3-bit digital control, two analog attenuators, shift registers for transmission of control data for adjustment of phases, analog automatic gain control (AGC) circuits, and status-monitoring circuits. Digital control signals and an RF signal are fed to the SLIC module via a single photonic link. This combination of signals is detected by a positive/intrinsic/negative (PIN) diode in the module, then separated by other circuitry into control and RF components. The RF signal is amplified and split eight ways to feed the four dual-channel RF MMICs. A peak detector at the output terminal of each channel on each RF MMIC samples the output signal level; this level is compared with a commanded level in the corresponding AGC circuit, which adjusts the setting of an attenuator to maintain the channel output at the commanded level.

*This work was done by John Windyka and Ed Zablocki of Sanders for* **Lewis Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Circuits category.*

*Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7–3, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16627.*

# Electronic Systems

## Computers for Research on Flight Control in F/A-18 Airplanes

### The cost of testing innovative control laws is expected to be reduced.

*Dryden Flight Research Center, Edwards, California*

The Production Support Flight Control Computers (PSFCCs) are flight-control computers that are being developed by NASA in conjunction with the United States Navy. These computers are designed to provide any of the F/A-18 airplanes at NASA Dryden Flight Research Center with capabilities for research in flight-control laws and integrated propulsion/flight-control concepts.

The PSFCCs were conceived to satisfy a need to be able to conduct safe, fast, and efficient flight tests of advanced control laws and handling qualities, on a time-available basis. In the past, design, implementation, and testing of control laws have been extremely expensive and connected directly with specific flight programs under tight schedules. The use of the PSFCCs is intended to reduce the time and cost associated with implementation of new control laws and to enable control-law researchers to spend more time for investigation and discovery in the flight environment.

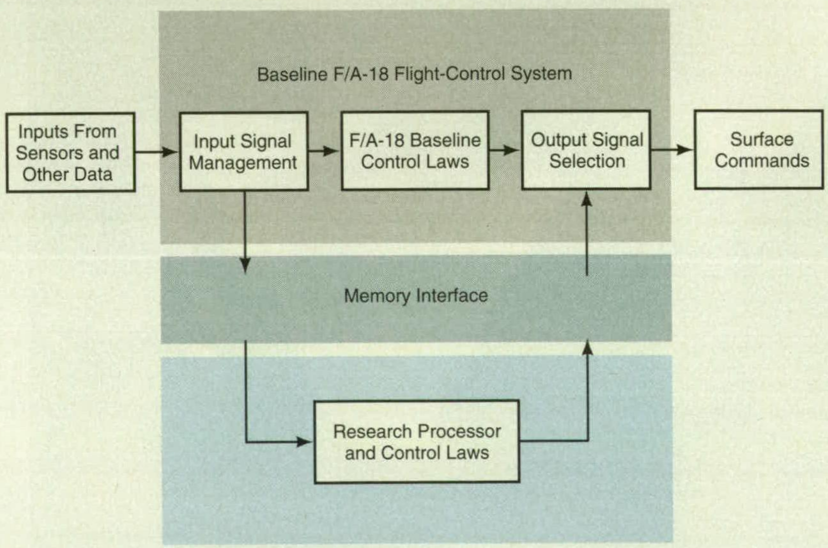
A PSFCC includes a research control-law processor embedded in the flight-control-computer avionics box of an F/A-18 airplane (see figure). The PSFCC enables the pilot to select among research control laws and provides control access to flight-control surfaces and engines. The PSFCC maintains the F/A-18 redundancy-management features and enables immediate return to standard F/A-18 control laws.

The PSFCCs will enable flight testing of new control-law designs with a minimum of system software testing, thereby reducing the time and effort necessary for flight test of new control laws. Because a PSFCC can be installed on any F/A-18 airplane, no dedicated research aircraft is needed; this reduces the schedule and programmatic pressures on control-law researchers.

At present, the PSFCCs have gone through initial flight test and are being prepared for initial experiments involving alternate control sticks, flexible-wing parameter identification, and aircraft formation flight.

*This work was done by John Carter of* **Dryden Flight Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Systems category. DRC-98-78*


AIRPLANE DURING A TEST FLIGHT




INTEGRATION OF PSFCC INTO BASELINE F/A-18 FLIGHT-CONTROL COMPUTERS

**A PSFCC Is Integrated** into a baseline F/A-18 flight-control system. A PSFCC can be installed in any F/A-18 airplane that happens to be available for a flight test.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# Information-Reduced Carrier Synchronization for Coded PSK Operation at Low-SNR

## Symbol (and thus phase) estimates are improved iteratively.

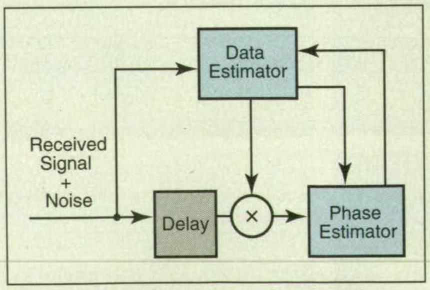
*NASA's Jet Propulsion Laboratory, Pasadena, California*

An information-reduced carrier-synchronization (IRCS) system has been proposed for use in a coded binary-phase-shift-keying (BPSK) radio-communication receiver subject to a low signal-to-noise ratio (SNR). The term "information-reduced" alludes to the use of an estimate of the instantaneous data symbol (and thus of the instantaneous phase modulation) to reduce the amount of randomness (and thus the amount of information) in the signal being processed in the carrier synchronizer.

In IRCS, the reduction of the amount of information is effected by attempting to convert the received modulated carrier to an unmodulated carrier (pure tone) before applying it to a phase-tracking loop, in the hope of improving performance. Traditional IRCS systems for synchronization with carrier signals modulated by BPSK include Costas loops, data-aided loops, and demodulation/remodulation loops. The traditional systems are designed to implement various approximations of a closed-loop structure that effects maximum *a posteriori* (MAP) estimation of phase. The degradation of tracking performance of such a loop in the case of BPSK is represented by a quantity called the "squaring loss," which is a measure of the degradation of the receiver signal-to-noise ratio and is associated with the mean-squared phase error of the loop. In the case of a conventional in-phase/quadrature (I-Q) carrier-tracking loop, the mean-square phase error is a result of signal and noise cross products that are generated in the effort to remove the data modulation from the loop error signal. At low symbol SNR, the squaring loss of an I-Q loop can be severe enough to prevent tracking.

If the data sequence and its timing were completely known, then a BPSK signal could be converted to a pure tone simply by multiplying the BPSK signal by the data waveform. One could then track the unmodulated carrier with improved performance by use of a phase-locked loop, which does not exhibit squaring loss. Short of complete knowledge of the data waveform and in the presence of noise, the best approximation of a pure tone could be obtained by feeding back an estimate of the data waveform corresponding to tentative decisions on the data symbols. Such feedback is called "decision feedback" for short.






The **Proposed Information-Reduced Carrier-Synchronization System** would effect an iterative process in which data estimates would result in improved phase estimates which would result in improved data estimates, and so on. Theoretical calculations have shown that in comparison with other carrier-synchronization systems for coded BPSK, this system would offer superior tracking performance.

Decision feedback is used within the traditional loops, but is not used to modify the loop structures. In the proposed IRCS system (see figure), decision feedback would be introduced at the input terminal of the loop; simultaneously, the structure of the loop would be modified (in the sense that its parameters would be modified) on the basis of the associated change in data-transition statistics in the input. The transition probability would be reduced from 1/2 (characteristic of BPSK signals in the absence of feedback) to a value closer to zero, so that the input signal would be converted to a close approximation of a pure tone, with a resultant improvement in carrier-tracking performance over conventional I-Q loops.

Although initially available data-waveform estimates are generally of low quality, they can be used to initiate the IRCS process by reducing the number of data transitions at the input. Once phase lock was achieved, the improved phase estimates could be fed back to the data detector, yielding improved symbol estimates for feedback, and thereby achieving even better phase tracking. This iterative process could eventually lead to virtual elimination of squaring loss, so that the performance of the system would approach that of a phase-locked loop operating on an unmodulated carrier signal.

*This work was done by Victor Vilnrotter and Marvin Simon of Caltech for* **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Systems category. NPO-20261*

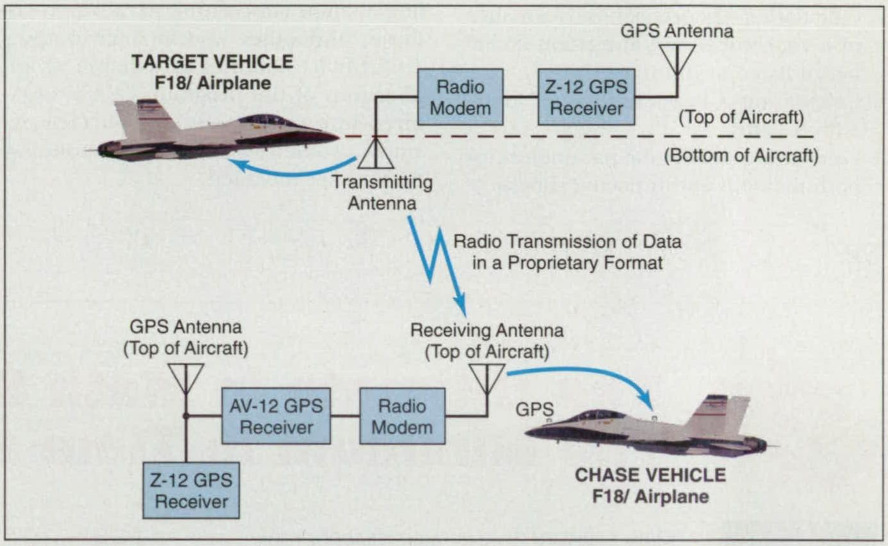
# GPS-Based System Tracks Relative Position of Two Airplanes

## Data from this system will be used to control precise maneuvers for schlieren photography.

*Dryden Flight Research Center, Edwards, California*

A developmental electronic system that includes Global Positioning System (GPS) receivers is designed to track the relative position and velocity to two airplanes in real time. In the original application for which the system is being developed, one F-18 airplane (denoted the "chase vehicle") is to be used to take schlieren photographs of shock waves generated by the another F-18 airplane (denoted the "target vehicle"). When fully developed, the system would afford the precise position and time measurements needed to accomplish the schlieren shock-wave photography.

The system includes two GPS receivers (of types called "AV-12" and "Z-12") connected to the same antenna in the chase vehicle, and a single Z-12 GPS receiver in the target vehicle. Special-purpose software in the AV-12 receiver in the chase vehicle determines the absolute position of the chase vehicle by use of data received via the L1 [coarse-acquisition (C/A) GPS Code]. Before the relative position and velocity can be determined, the AV-12 receiver in the chase vehicle must receive GPS data from the Z-12 GPS receiver in the target vehicle. These data are transmitted to the chase vehicle as part of a message in a proprietary format. The relative-position and relative-velocity data can be used three ways: (1) viewed in real time on a display on the AV-12 receiver, (2) passed on to other computers, and (3) stored for later evaluation.




A **GPS-Based System** comprising subsystems in both airplanes provides data on their relative position and velocity.

Previous tests of the system were performed on the ground. Flight tests now under way involve the following operations:

- Simultaneously with the operation of the GPS receivers in the chase vehicle, the Z-12 receiver in the target vehicle logs its own position data. These data are downloaded to a laptop computer after a flight test for post-processing correction.
- The output data from the AV-12 receiver in the chase vehicle are saved in the aircraft data recording system. The data from the Z-12 receiver in the chase vehicle are taken to indicate the position of the chase vehicle and are logged internally. A laptop computer is used to download the data from this Z-12 receiver after a flight test, also for post-processing correction.

Preliminary results of the flight tests include observations of unexpected dropouts in the relative-position calculations. This observation indicates a need for tests to verify the quality of the communication lines between the transmitting and receiving antennas and the radio modems.

When dropouts do not occur, the accuracy achieved in flight tests is characterized by lateral position errors within ±3 m and vertical position errors within ±4 m with 2-m bias. This level of accuracy is more than adequate for schlieren photography between aircraft using the Sun as the light source. In planned flight tests, the data generated by the developmental system will be used, during subsonic flight of the chase vehicle and supersonic flight of the target vehicle, to momentarily position the chase vehicle to eclipse the Sun as viewed from the target vehicle. The data will also be used to trigger the photograph at the precise time of the artificial eclipse thus produced. The goal is to make detailed photographs of shock waves about the target vehicle.

*This work was done by Edward A. Haering, Jr., and Glenn Bever of* **Dryden Flight Research Center** *and Joe Collura of TYBRIN Corp. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Systems category. DRC-98-80*

# Software

## Program Computes Equilibrium Compositions of Mixtures

The Chemical Equilibrium with Applications (CEA) computer program is used to obtain chemical-equilibrium compositions of complex mixtures. This program can be applied to a wide variety of problems in chemistry and chemical engineering. Specifically, CEA is applicable to the following kinds of problems:

1. Obtaining chemical-equilibrium compositions for assigned thermodynamic states;
2. Calculating theoretical performance of a rocket with a combustion chamber of finite or infinite area;
3. Calculating Chapman-Jouguet detonations; and
4. Calculating shock-tube parameters for both incident and reflected shocks.

CEA requires two types of input. The first type is of thermodynamic data and thermal-transport-property data for individual species. These data accompany the program but the user can modify them. Approximately 1,340 reaction products and 60 reactants are included in the thermodynamic-data file. The second type comprises seven categories of problem-input data prepared by the user. These data are grouped into input sets in a general free format.

The program prints five kinds of output: the input data for the given problem, tables of results, files for plotting, information concerning iterative procedures, and other intermediate output. To facilitate addition or deletion of applications of the program, CEA is organized into eight modules. Fourteen example problems and the corresponding outputs are included.

CEA is written in ANSI standard FORTRAN 77 to be machine-independent. A FORTRAN 77 compiler is required. CEA has been successfully implemented on a '586-class IBM personal computer running Windows 95/NT 4.0, an HP9000/720 computer running HP-UX 9.03, and an SGI IRIS Indigo2 computer running IRIX 6.2. The standard distribution medium for CEA is one 3.5-in. (8.89 cm), 1.44MB, MS-DOS-format diskette. Alternate distribution media are available on request.

*This program was written by Bonnie J. McBride of* **Lewis Research Center** *and Sanford Gordon, Consultant. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Software category.*
*LEW-16645*

# Improved Process for Scrubbing and Treating $NO_x$ Liquor

## The pH and $H_2O_2$ are controlled to produce potassium nitrate fertilizer while scrubbing.

*John F. Kennedy Space Center, Florida*

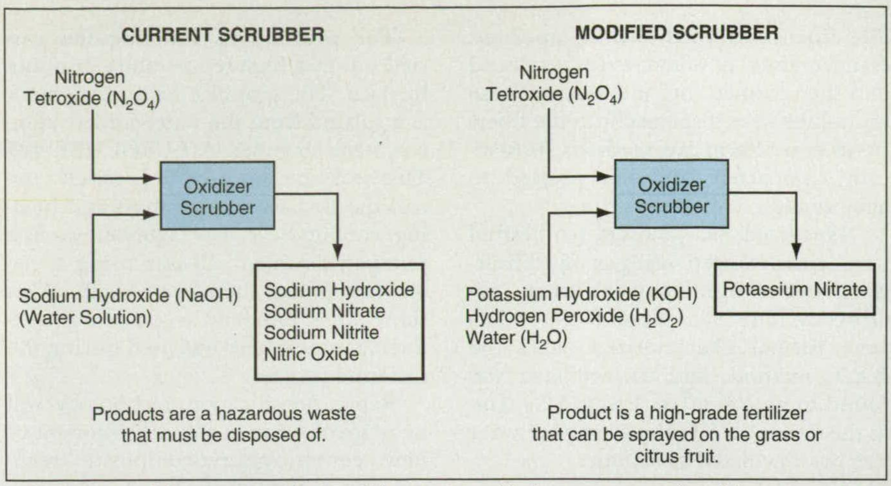
A new process and equipment have been developed for reducing the emissions of hazardous nitrogen oxides ($NO_x$), and eliminating a hazardous waste stream. In this process, a waste gas stream of nitrogen and $NO_x$, arising from spacecraft-propellant operations, is reacted (scrubbed) with a dilute solution of hydrogen peroxide *(scrubber liquor)*. The resulting liquor is treated simultaneously with potassium hydroxide during the scrubbing operation to produce potassium nitrate. The overall effect of the process is to absorb $NO_x$ from the waste gas stream into the scrubber liquor where $NO_x$ is converted into an aqueous solution of potassium nitrate, which can be used as a fertilizer.

In the original application for which the process and equipment were developed, $NO_x$ is an undesired gaseous effluent from the handling of nitrogen tetroxide, a hypergolic propellant oxidizer used in space shuttle and Titan rockets. The process and equipment could also be adapted to removal of $NO_x$ from flue gases, ventilation streams from metal-pickling operations, and other gaseous effluent streams.

As in a typical scrubber process, the improved process has a scrubber liquor pumped to the top of a tower and sprayed down through packing, while the gaseous mixture rises through the column and is vented after being scrubbed by the falling liquor. The concentration of hydrogen peroxide ($H_2O_2$) is controlled to 1.0 percent in the liquor storage tank by automatic addition of 35-percent $H_2O_2$. Also, the pH is maintained at 7.0 by the automatic addition of potassium hydroxide solution.

Scrubber liquor is continually sampled during scrubbing to determine the pH and hydrogen peroxide concentration. A commercial controller monitors pH and adds 45-percent potassium hydroxide solution, as needed. The potassium hydroxide reacts with nitric acid produced in the liquor, as nitrogen tetroxide is scrubbed. As the liquor is recycled back to absorb more oxidizer, the concentration of potassium nitrate builds up to a maximum of 15 weight percent, after which it is stored in a separate tank for shipment to fertilizer use areas.

A new invention, the $NO_x$ control system including the hydrogen peroxide controller, repeatedly takes small samples of the scrubber liquor and measures




A **Comparison** of the current oxidizer scrubber process with the new proposed scrubber process shows the advantage of the modified configuration.

the peroxide content. A programmable logic controller activates switches, valves, and pumps to control the rate of addition of a 35-percent hydrogen peroxide solution to maintain a 1-percent peroxide concentration in the bulk liquor. The hydrogen peroxide controller (see figure) is based on the chemical reaction between hydrogen peroxide and sodium hypochlorite, ordinary household bleach:

$$H_2O_2 + NaOCl \rightarrow H_2O + NaCl + O_2$$

This reaction takes place in a closed vessel, so that the increase in pressure from generation of $O_2$ can be measured as an indication of the amount of $H_2O_2$ in the sampled scrubber liquor.

The improved process is intended to replace an existing process in which the scrubber liquor is a 25-weight-percent solution of sodium hydroxide. When all impacts of both processes are considered, the improved process is found to cost less, to eliminate a hazardous waste stream, to lower $NO_x$ emissions, and to produce a valuable liquid fertilizer instead.

*This work was done by Dale E. Lueck of* **Kennedy Space Center** *and Clyde F. Parrish and Ronald G. Barile formerly of I-Net. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category.*

*This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Kennedy Space Center; (407) 867-6225. Refer to KSC-11884.*

# Rapid Densification of Ceramic Monoliths and Composites

## New technology enables rapid, low-cost manufacturing of partially-dense and fully-dense devices and components of ceramic compositions.

*Marshall Space Flight Center, Alabama*

A rapid densification technology uses nanostructured powders to produce ceramic devices and components. This technology provides ceramic monoliths and composites that can be used in the automobile, energy, electrochemical, magnetic, structural, biomedical, computing, information-transfer, and pollution-prevention-and-control industries.

Nanoscale powders of ceramic, measuring less than 100 nm, were mixed with less than 5 weight percent of sintering aid, cold pressed into pellets, and pressureless sintered between 1,400 and 1,600 °C. The sintering environment was evacuated to remove oxygen and maintained in evacuated reducing state.

Micron-scale powders of ceramics with the same composition were also processed through the same steps under similar environments.

The densification of a ceramic compact, or sintering, is the process of removing the pores between the starting particles combined with growth and strong bonding between adjacent particles. The driving force for densification is the decrease in surface area and lowering of the surface free energy by the elimination of the solid-vapor interface.

Nanostructured powders are a novel class of materials whose distinguishing feature is that their average grain or other structural domain sizes are below 100 nm. Within this size range, a variety of confinement effects significantly change the properties of the material. The confinement effects lead to several commercially useful characteristics. From a processing viewpoint, nanostructured powders offer the potential for very high sintering rates at lower temperatures.

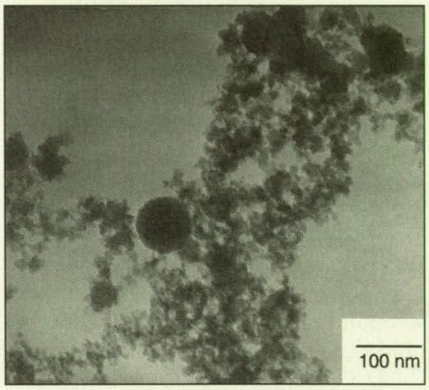
In order to reduce the concept of this new technology to practice, the innovators focused on $\beta$-SiC and continuous SiC fiber-reinforced SiC composites. Nanoceramic powders were produced and then formed into monoliths. These monoliths were dispersed into the fibers by several alternative methods, isostatically compacted, and hot pressed to achieve high densities.

Nano-sized SiC powders synthesized were characterized using x-ray diffraction and transmission electron microscopy. The nano-sized SiC powders were further characterized using the B.E.T. method, and surface area was found to be 100 $m^2/g$. Using 3.2 $g/cm^3$ as the density of SiC, the average powder size was calculated as 9.4 nm.

The pressureless sintering was carried out in a high-temperature graphite furnace. The graphite heating element is insulated from the water-cooled stainless steel chamber. A EUROCUBE 425 Thyristor unit was used to precisely control the furnace temperature and heating/cooling cycle. The chamber was first pumped down to ~10 torr using a mechanical pump, then flashed with argon three times. Either an argon or argon-reducing atmosphere was used during the sintering process.

Rapid densification technology will be of great value in the development of new ceramic-matrix-composite technologies of the future.





This image shows **Nano-Sized SiC Powders** (magnified 120,000 times).

With 10-nm-sized SiC nanopowders, monolithic SiC and SiC matrix composite samples were pressureless sintered to over 90 percent of the theoretical density in 240 minutes at 1,450 and 1,500 °C respectively. At temperatures such as those presently used in conventional SiC and SiC/SiC densification practices (>2,000 °C), the densification of nano-sized SiC and SiC/SiC is expected to be more than 30 times faster. Beyond processing benefits, the invention offers performance benefits as well. The densified composite samples prepared with nano-sized SiC, for example, offer much higher fracture strength (400 percent) than those prepared with micron-sized SiC as starting powders. This technology breakthrough is applicable to other commercially important carbide, nitride, boride, silicide, and oxide ceramic compound compositions as well.

*This work was done by Mark Liu Yang and Tapesh Yadav, Nano-materials Research Corporation, for the* **Marshall Space Flight Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category.*

*Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-26458.*

# Special Coverage: Mechanical Technology

## Replaceable Windows With Alignment and Sealing Features

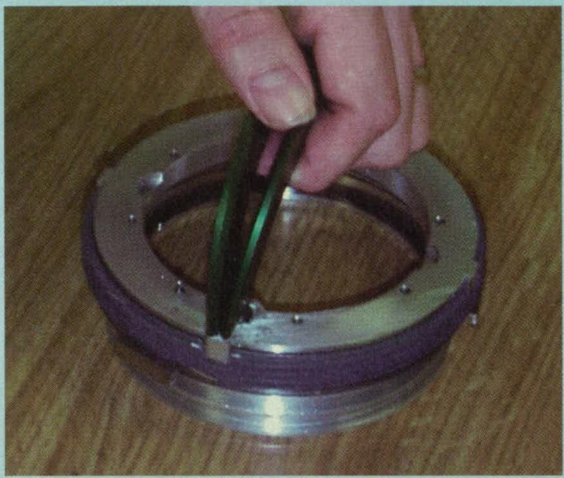
### Installation and removal can be accomplished without tools.

*Lewis Research Center, Cleveland, Ohio*

Window assemblies (see figure) have been developed to satisfy special requirements pertaining to ease of replacement, alignment, sealing, and resistance to vibration in a spaceborne laboratory apparatus for experiments on combustion in microgravity. These window assemblies are also well suited to a variety of terrestrial applications; for example, they could used as observation ports or as mechanical or electrical feedthrough devices on industrial process chambers, vacuum chambers, or oceanographic equipment.

The windows can be installed and removed manually, without tools. Each window mates with a seat that is a permanent part of the chamber in which the window is to be installed. All one need do to install a window is to align it approximately with the seat, then rotate the window one turn. The rotation brings the window into alignment, brings sealing surfaces together to make a vacuum- or pressure-tight seal, and provides a vibration-proof connection. The window gives a firm feel when it becomes seated.

This mode of operation of the window is established by a unique combination of threads, sealing features, and a ratchet. A multiple-lead acme thread ensures an easy start. Because the seal acts on a bore in the chamber wall, instead of on a face parallel to the plane of the window, there is no need for the large clamping force that would be needed for a face seal. The ratchet includes a spring-loaded dimple plate acting on tapered lands. The lands are cut steeper in the window-removal than in the window-installation direction, so that more torque is needed to remove than to install the window; this feature helps to prevent loosening in the presence of vibrations.



Window Assembly Showing Handle (in Green) Folded Up for Installation

Window Assembly Showing Acme Thread and Sealing Surfaces

**No Tools Are Needed** to install or remove these windows, which are simply inserted in approximate initial alignment, then rotated to obtain precise alignment and tight seals. Windows can be used for observation or as feedthrough devices.

*This work was done by Malcolm Robbie of Analex Corp. and Raymond Homyk of ADF for* **Lewis Research Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at*** ***www.nasatech.com*** *under the Mechanics category.*

*Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7–3, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16529.*

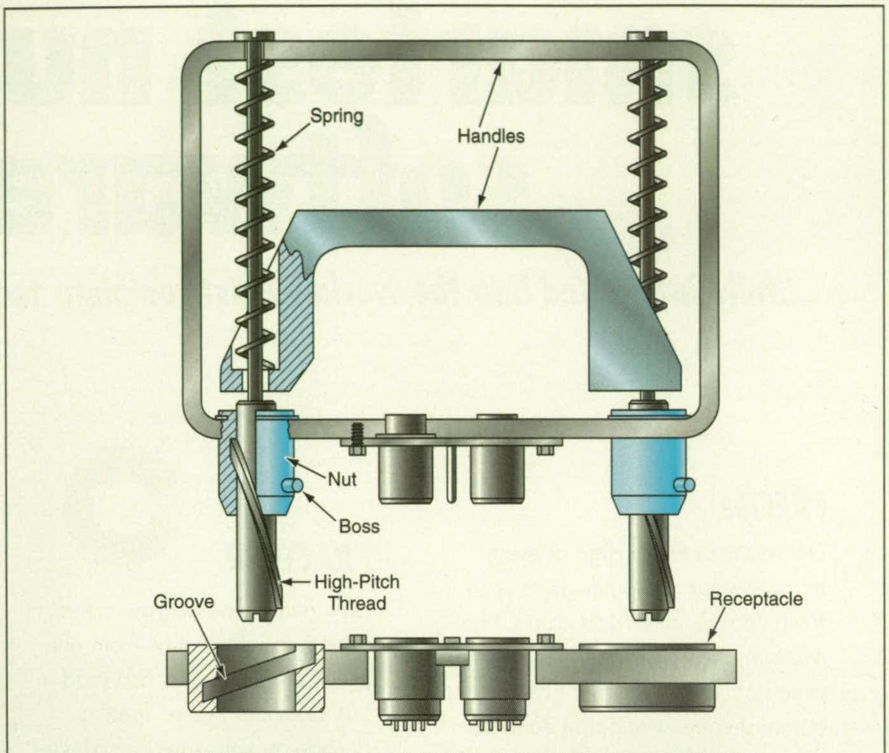
# Latching Devices for Electrical and Mechanical Connections

**Connections can be made or broken quickly by simple hand motions, without tools.**

*Lewis Research Center, Cleveland, Ohio*

Latching devices have been developed to provide electrical connections, secure mechanical and thermal connections, and optical alignment for mounting electronically controlled cameras on the spaceborne laboratory apparatus described in the preceding article. Traditionally, the installation of such a camera or a similar instrument has been a time-consuming task that involved tightening of multiple fasteners to specified torques, making separate electrical connections, and use of special tools. The present latching devices are designed for quick connection and quick disconnection by simple manual hand motions; no tools are needed. These latching devices could also be used on Earth in numerous industrial and scientific applications to provide electrical, mechanical, thermal, and/or optical interconnections that can be made and broken quickly and reliably, without tools.

Each latching device comprises two mating subassemblies (see figure). The operation of the latching device depends on a unique combination of threaded parts. The inner spring-loaded handle is connected to the rods, which are not free to rotate. A single high-pitch thread on each rod engages a nut that is free to rotate but not to translate along its axis of rotation. A boss on each nut engages a lower-pitch groove in its mating receptacle, each of which is free to rotate with respect to the handle.




The **Two Mating Subassemblies** can be connected and disconnected quickly by simple hand motions.

To connect the two subassemblies, one simply squeezes together the two spring-loaded handles on one subassembly, inserts the rods and nuts protruding from that subassembly into mating receptacles on the other subassembly, then releases the handles. The initial squeezing of the handles causes the nuts to rotate to an angular position in which the bosses on the nuts are aligned with the openings to the grooves in the receptacles. The release of the handle causes the nuts to rotate in a direction to make the bosses slide along the grooves deeper into the receptacles, thereby drawing the two subassemblies together at a common surface. In the original application, the contact at the common surface brings the camera into alignment with an optical reference surface. The force clamping the two subassemblies together is generated by the spring and multiplied by a mechanical advantage proportional to the ratio between the pitch of the thread and the pitch of the groove. By use of low-friction coating material on the threads, grooves, and bosses, the achievable clamping force can be made to approach the ideal clamping force more closely.

*This work was done by Malcolm Robbie of Analex Corp. for* **Lewis Research Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mechanics category.*

*Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7–3, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16528.*

# Penetrator Projectile Tolerates Some Misalignment

**A forebody/afterbody design prevents buckling and ensures penetration.**

*NASA's Jet Propulsion Laboratory, Pasadena, California*

A two-body design has enabled an instrumented penetrator projectile to function with increased tolerance to initial misalignment among (a) the longitudinal axis of the penetrator, (b) the velocity of impact on the ground, and (c) the local perpendicular to the surface at the point of impact. In the original application, the two-body penetrator will be launched from a spacecraft to impinge on Mars, where it will sample the soil. The two-body penetrator design is easily adaptable to instrumented penetrators for sampling subsurface materials in sand, soil, mud, snow, or ice in hostile or inaccessible environments on Earth.

Older instrumented-penetrator designs feature unitary bodies that are much longer than they are wide. In a typical case, if the longitudinal axis of

the body deviates from impact velocity direction by an angle of more than about 6°, then the penetrator buckles and/or fails to penetrate.

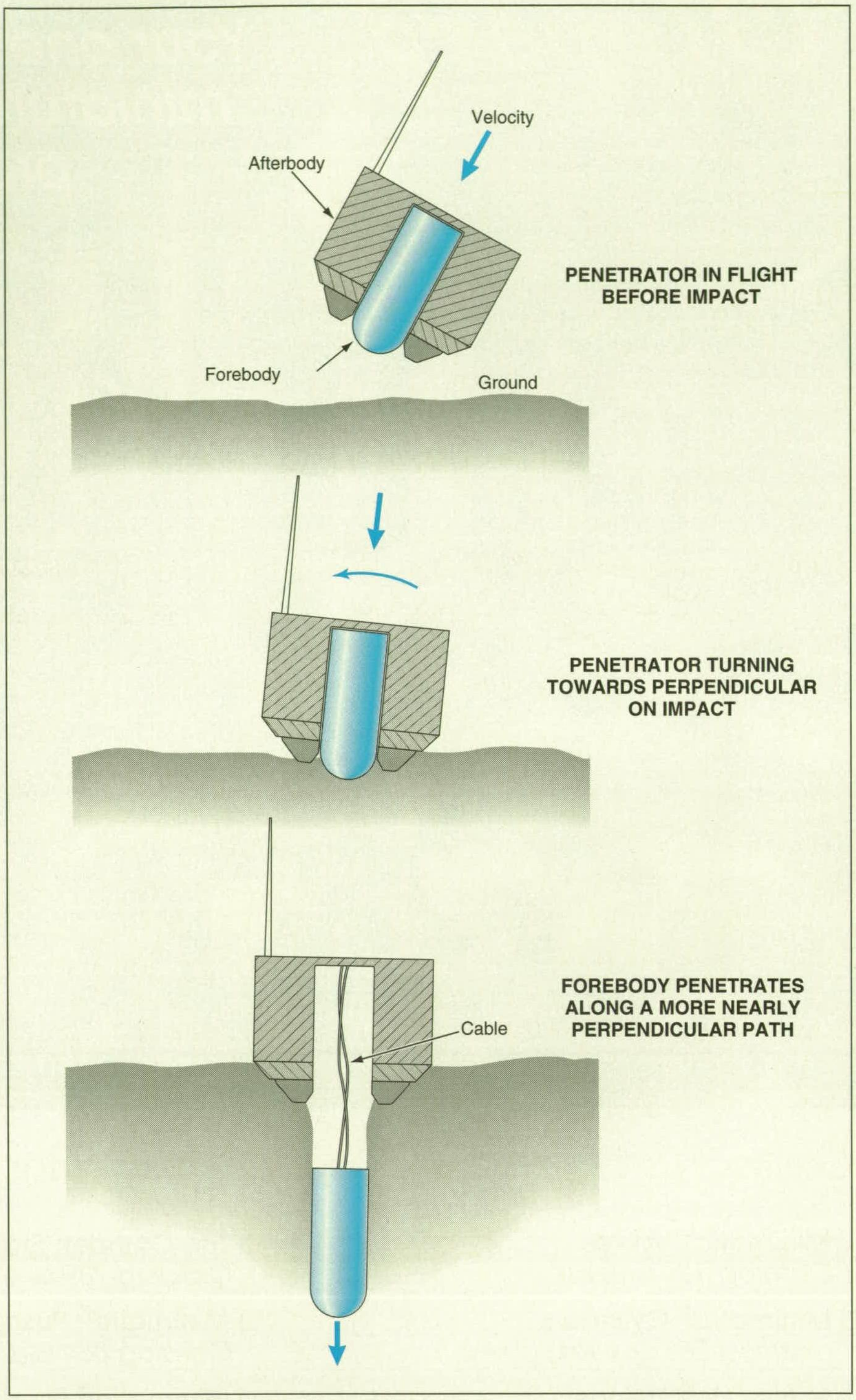
The two-body penetrator (see figure) includes a forebody and an afterbody. The forebody contains the instrumentation and machinery required to penetrate the ground; the forebody has a hemispherical tip and is shorter and stubbier, in comparison to a typical older unitary penetrator. The afterbody contains batteries, radio-communication circuitry, and those sensors (e.g., a Sun sensor and an atmospheric-pressure sensor) that must not penetrate the ground. Prior to impact, the forebody is stowed in a longitudinal cylindrical recess in the afterbody.

Upon impact, a flange on the bottom of the afterbody becomes braked upon contact with the ground. The braking action is such that in the presence of misalignment, the afterbody turns so that the recess holding the forebody becomes aligned more nearly perpendicularly to the ground surface. As the afterbody decelerates, the forebody slides out of the recess, penetrating the ground underneath the afterbody. The forebody and afterbody remain connected by a flexible cable that pays out from the forebody during impact.

The concept has been tested in experiments in which two-body penetrators were fired from an air gun into sand, soil, and cement-mix targets at speeds from 168 to 208 m/s. In one test in which a penetrator was fired into the ground at an angle of 75° with the surface, the forebody was found to have traveled into the soil at an angle of 83° with the surface; that is, more nearly perpendicularly to the surface, as intended.

*This work was done by Donald Bickler and Tommaso Rivellini of Caltech for* **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mechanics category.*

*NPO-20295*




The **Afterbody Is Braked and Turned** upon impact to face more directly down into the ground. The forebody separates from the afterbody and penetrates a short distance below the surface.

# Fabricating Refractory-Metal Solar-Engine Components by VPS

## Little or no ancillary machining is necessary.

*Marshall Space Flight Center, Alabama*

Vacuum plasma spraying (VPS) has been demonstrated to be an effective technique for the fabrication of refractory-metal components of solar-thermal engines. Heretofore, such components have been fabricated by specialized techniques that include electrical-discharge machining, shear spinning, sintering under pressure, chemical vapor deposition, and electrochemical machining. Though effective, these specialized techniques are time-consuming and costly. On the other hand, VPS makes it possible to fabricate components with complex shapes, simply and at relatively low cost.

VPS is a thermal-spray process conducted in a low-pressure, inert-gas atmosphere. A hot plasma is generated by making an inert gas flow through a direct-current arc. The plasma flows through a nozzle to a downstream vacuum chamber, where the pressure is maintained at about 100 torr (about 13 kPa) and the deposition substrate is located. A powder of the material to be deposited is injected into the plasma, causing the material to be heated and accelerated toward the substrate. The process is continued until the deposit reaches the desired thickness.

In the present application of VPS, the substrates used to form solar-thermal-engine components are graphite mandrels. Each mandrel acts as a male mold to form the inside of the deposit to the required size, shape, and surface finish. Inasmuch as graphite is soft and easy to machine, complex shapes and precise surface textures can be achieved without difficulty. For example, helical flow channels for transfer of heat to a working fluid can be formed integrally into a component of a generally cylindrical absorber cavity (see figure), and textures necessary for maximizing absorption of solar radiation can be imparted to the inner surface of the cavity by the outer surface of the mandrel used to make the innermost component.

After the refractory metal has been deposited to the desired thickness, the mandrel is removed by blasting with acrylic or other polymeric beads, which are hard enough for eroding the graphite but soft enough not to damage the refractory-metal deposit. Removal of the graphite in this manner is rapid and simple and complies with environmental laws.

Because the interior of a component formed by VPS is inherently of net size, shape, and surface finish imparted by the mandrel, no additional machining or surface conditioning of the interior is necessary. The exterior dimensions can be controlled by controlling the deposition rate and time, so that the exterior of the VPS-formed component is near net size and shape. Thus, little or no subsequent machining is necessary; this is especially advantageous for fabricating components of tungsten, rhenium, and molybdenum, which are difficult to machine by conventional techniques. Even in cases in which tolerances are tighter than are achievable by VPS, the amount of subsequent machining and grinding needed is less than in older methods and is confined to exterior surfaces, which are more accessible than interior surfaces are. While VPS shares these advantages with other vacuum-vapor-deposition processes (chemical vapor deposition and physical vapor deposition), VPS deposits materials at

**Vacuum Plasma Spraying** was used to make all of these parts except the flange with holes. The item at the right comprises three concentric shells.

rates orders of magnitude greater than those of the other processes.

*This work was done by Frank R. Zimmerman, D. Andy Hissam, and Harold P. Gerrish of* **Marshall Space Flight Center** *and William Davis of Boeing North American. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Manufacturing/Fabrication category.*

*Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-31242.*

# Robot Hands With Electroactive-Polymer Fingers

## The fingers function similarly to human fingers.

*NASA's Jet Propulsion Laboratory, Pasadena, California*

Multifinger electroactive-polymer grippers (MEPGs) are simple, compact, lightweight robotic end effectors with fingers that bend and function similarly to human fingers. The fingers are made from electroactive polymers, which are well suited to use in bending-type actuators because they can be formed into various shapes, are flexible and tough, and damp vibrations. In comparison with electroactive ceramics, electroactive polymers are much lighter and exhibit about 100 times as much actuation strain. Like other polymers, electroactive polymers can be mass-produced at relatively low cost.

More specifically, the fingers of MEPGs are made from ion-exchange membrane platinum (IEMP) composite polymers. When a voltage is applied across the thickness of such a finger, electrostriction in the polymer causes the finger to bend; the direction of bending depends on the polarity of the voltage.

The figure illustrates an MEPG with two opposed fingers wired in antiparallel so that they will bend in opposite directions (and thus toward or away from each other) in response to an applied voltage. The angle of bending of a finger can exceed 120°. Typically, a finger is driven with a potential of about 5 V and consumes a power of about 25 mW.

In a typical operational sequence, a voltage of one polarity is applied to spread the fingers apart to clear an object as the hand approaches the object. Once the hand is positioned over the object with a finger on each side, the polarity is reversed to close the fingers around the object. Hooks on the ends of the fingers (somewhat analogous to fingernails) help to secure the grip on the object, which can be picked up and carried once the fingers close around it. In experiments, a two-finger prototype hand lifted a rod with a mass of 1.5 g, and a four-finger prototype hand lifted a rod with a mass of 10.3 g.

*This work was done by Yoseph Bar-Cohen, Tianji Xue, Mohsen Shahinpoor, and Shyh-Shiuh Lih of Caltech for* **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mechanics category.*

*In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to*

*Technology Reporting Office*
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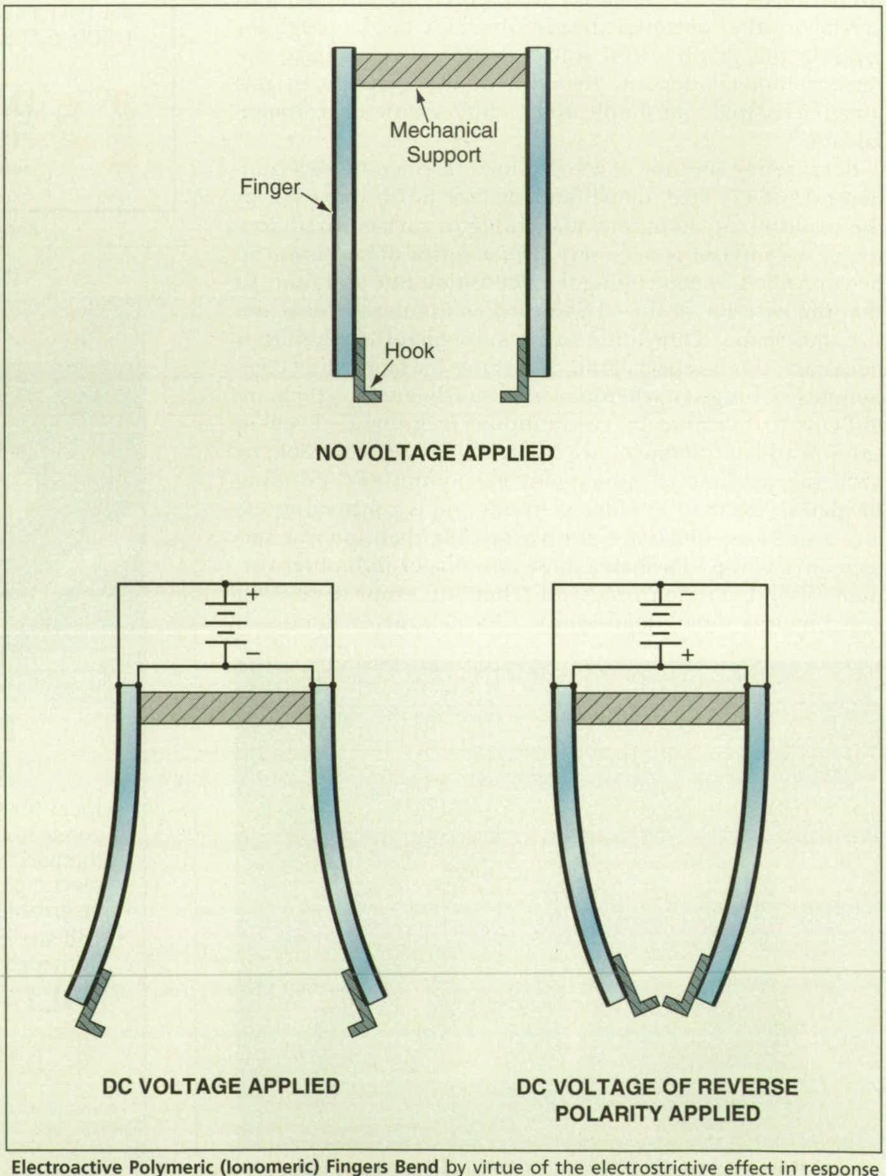
*4800 Oak Grove Drive*
*Pasadena, CA 91109*
*(818) 354-2240*

*Refer to NPO-20103, volume and number of this* NASA Tech Briefs *issue, and the page number.*




**Electroactive Polymeric (Ionomeric) Fingers Bend** by virtue of the electrostrictive effect in response to applied voltage. The direction of bending depends on the polarity of the voltage.

# Vacuum Three-Ball Tribometer for Testing Liquid Lubricants

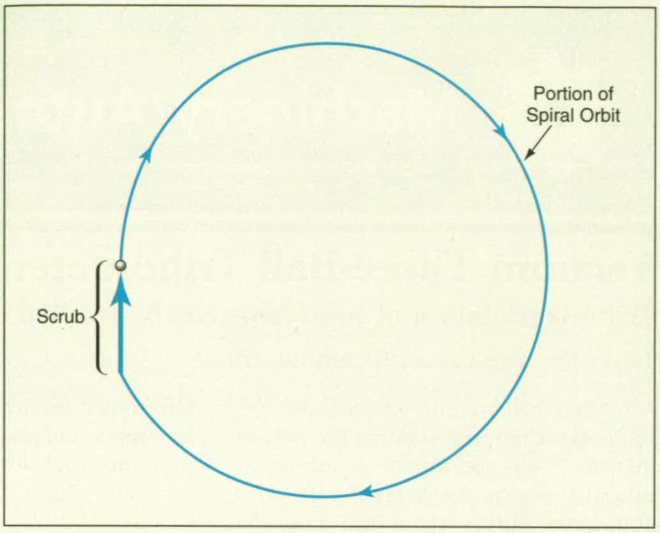
**Tribodegradation of lubricants can be studied under controlled, realistic conditions.**

*Lewis Research Center, Cleveland, Ohio*

A three-ball tribometer has been developed for use in evaluating the performances of oils and greases as lubricants in a vacuum at room temperature. This apparatus differs from the one described in "Vacuum Four-Ball Tribometer for Testing Liquid Lubricants" (LEW-16194), *NASA Tech Briefs,* Vol. 21, No. 4 (April 1997), page 64. The present apparatus is designed especially for experiments on the tribodegradation of liquid lubricants under conditions similar to those observed in preloaded angular-contact ball bearings operating in the boundary-lubrication regime in a vacuum. Tribodegradation can include both physical and chemical changes caused by a combination of contact stresses and aggressive ambient conditions. The chemical changes typically involve chemical reactions between lubricants and bearing surfaces, decomposition of lubricants, and darkening of lubricants associated with the formation of products denoted generally as "friction polymers."

The tribometer is housed in a stainless steel vacuum chamber. The main tribological assembly is a retainerless steel thrust bearing with three balls of 0.5-in. (12.7-mm) diameter placed symmetrically between flat races. The balls and plates are made of 440C stainless steel, which is commonly used in instrument ball bearings. The bottom plate is mounted on a shaft that passes out of the vacuum chamber through a steel bellows and is connected via a load cell to a deadweight cantilever device that pushes the bottom plate upward to apply the preload. A preload of 100 lbf (445 N) provides a mean Hertz (contact) stress of 1.39 GPa, which is typical for a preloaded instrument bearing. The bottom plate does not rotate. Driven by a synchronous gearmotor via a ferrofluidic rotary feedthrough, the top plate rotates at 4 rpm. Such a low speed helps to ensure the desired room-temperature test condition.

The rotation of the top plate causes the balls to roll on the bottom plate in an almost circular orbit of about 21-mm radius. More precisely, the balls gradually spiral outward from their initial radii with a pitch of about 0.5 mm per revolution and would eventually fall out if allowed to continue rolling without the restraint provided by a guide plate. The balls eventually make contact with the




The **Balls Move in a Stable Orbit** comprising spiral and scrub portions, the dynamics of which are not yet well understood. Further study of the dynamics is expected to contribute to understanding of liquid-lubricated rolling friction.

guide plate for a distance of about 5 mm, where they move along a straight line called the "scrub" and are forced back to the initial, slightly smaller orbit radius. Together, the spiral and scrub portions of the orbit constitute a track (see figure) that is stable and repeatable and is traversed thousands of times by the balls during an experiment. The scrub is also utilized to measure the coefficient of friction; this measurement is accomplished by use of a load cell that supports the guide plate and measures the force exerted on the guide plate by each passing ball. To ensure that bulk temperatures remain near room temperature and to prevent metallic wear, an experiment is stopped at the first sign of increased friction.

Once the vacuum chamber has been evacuated and an experiment is in progress, a residual-gas analyzer with a line of sight to the balls and plates is used to determine the composition of residual gas from the chamber and of any molecular species that evolve through tribodegradation of the lubricant. After an experiment, the degraded lubricant can easily be examined by use of such surface- and thin-film-analysis techniques as optical and electron microscopy, photoelectron spectroscopy, and infrared and Raman microspectroscopy.

The design of this tribometer offers several advantages. It provides a more credible simulation of preloaded angular-contact ball bearings operating in the boundary-lubrication regime than does a tribometer containing a ball sliding on a plate. Retainerless operation eliminates forces associated with balls sliding in retainer pockets and thereby enables a simple yet rigorous analysis of stresses to which a lubricant is subjected. The absence of a porous retainer eliminates the uncertainties associated with a supply of lubricant; the bearing is forced to operate with an extremely small lubricant charge, so that there is maximum opportunity for the lubricant to be tribologically exercised to make it undergo tribodegradation. The balls and plates are inexpensive. Surface analyses of tracks can be performed more easily on the flat plates of this tribometer than on the curved surfaces of ordinary bearing races.

*This work was done by Stephen V. Pepper and Ben T. Ebihara of* **Lewis Research Center** *and Edward Kingsbury of Interesting Rolling Contact. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Machinery/Fabrication category.*

*Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7–3, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16550.*

# Improved Packaging of Silica Optical Fibers in Sensor Heads

**Fibers would be held in metal ferrules by matrices of fused glass.**

*Lewis Research Center, Cleveland, Ohio*

A process for the fabrication of improved high-temperature fiber-optic sensor heads has been proposed. Fiber-optic sensor heads that can withstand hot, dirty, noisy environments are needed for advanced jet engines and stationary power-generating turbine engines.

A typical optical fiber for high-temperature service is made of fused silica. Also typically, the surface layer of the fiber is doped with germanium to alter its index of refraction in such a way as to achieve a specific numerical aperture needed for directionally selective sensing. Engine operating temperatures to which silica optical fibers are likely to be exposed range up to somewhat above 250 °C, and the fibers can withstand higher temperatures up to 700 °C. Prolonged exposure to temperatures above 700 °C causes diffusion of germanium from the surface layers into the pure fused silica cores of the fibers, with consequent loss of the desired numerical apertures. Accordingly, any heating that must be performed in fabricating a sensor head should be limited to temperatures below 700 °C.

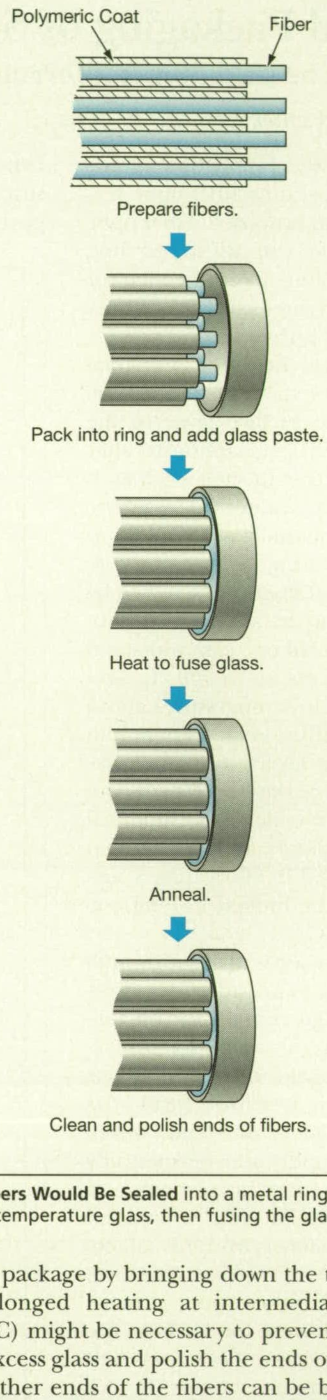
A fiber-optic sensor is made with multiple optical fibers to provide (1) a cross-sectional area large enough for reliable sensing and (2) redundancy for protection against breakage of one or more fiber(s). To form a sensor head, the fibers are bundled at one end, where they are sealed rigidly and hermetically in a ring sized to fit an instrumentation port in an engine. The ring is made of Kovar (or equivalent) iron/nickel/cobalt alloy.

The proposed fabrication process would include a step for sealing the fibers into the ring by use of a glass that melts at a temperature below 700 °C. The process (see figure) would comprise the following steps:

1. Prepare the requisite number of silica fibers of equal length. Such fibers are supplied with polyimide or nylon coats. Strip off about 1 in. (about 2.5 cm) of the coat at one end of each fiber. The polymeric coating material will not survive the high temperature to which the stripped ends will subsequently be exposed, but elsewhere than at the stripped ends it provides mechanical support and thus should be left intact.
2. Pack the fibers in the ring. Fill the interstices between fibers and the space between the fibers and the ring with a

boric-glass paste. If necessary, install fixtures to hold the fibers steady in the ring.

3. Using a controllable source of heat, raise the temperature of the glass paste to at least the melting temperature of the boric glass (580 °C) but no more than 700 °C. Continue heating until the paste fuses and bonds to the fiber surfaces.




**Silica Optical Fibers Would Be Sealed** into a metal ring by applying a paste of low-melting-temperature glass, then fusing the glass.

4. Anneal the package by bringing down the temperature very slowly. Prolonged heating at intermediate temperatures (e.g., 500 °C) might be necessary to prevent cracking.
5. Clean off excess glass and polish the ends of the fibers in the ring. The other ends of the fibers can be bundled as a conventional fiber-optic cable because they will not be exposed to high operating temperatures.

*This work was done by E. Shu, W. Daum, and L. Petrucco of General Electric Co. for* **Lewis Research Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Manufacturing/Fabrication category.*

*Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7–3, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16264.*

# Microfabricated Ice Sensors

## Presence of ice is inferred from stiffening of a capacitive actuator/sensor.

*Lewis Research Center, Cleveland, Ohio*

Microfabricated, silicon-based capacitive actuator/sensor devices have been developed as prototypes of compact, low-power transducers that would be used to detect the presence (and perhaps eventually measure the thickness) of ice on aircraft lift and control surfaces. These transducers would be mounted flush with surfaces, so that they would not perturb airflows. Transducers of this type could also be used in such diverse applications as detecting ice in refrigerators for triggering defrosting cycles and detecting ice on roadways to trigger warning signals for drivers.

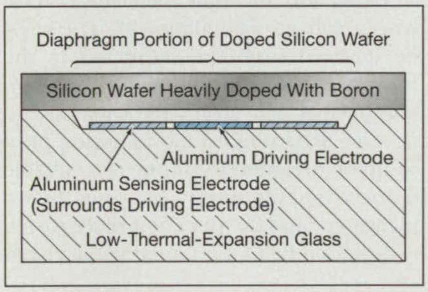



Figure 1. This **Microfabricated Actuator/Sensor Device** is used to detect ice on the upper (outer) diaphragm surface. The diaphragm is deflected electrostatically by application of voltage to the driving electrode. The amount of deflection (which decreases in the presence of ice) is measured capacitively via the sensing electrode.

Figure 1 presents a simplified cross-sectional view to illustrate the basic device configuration and ice-detection principle. The main supporting structure is a low-thermal-expansion glass wafer containing a rectangular hole 1 to 3 mm on a side and about 2 to 3 μm deep on its upper surface. The glass wafer is capped by a 7-μm-thick silicon wafer that has been heavily doped with boron to make it highly electrically conductive. The part of the wafer over the hole constitutes both a diaphragm and one electrode of a three-electrode parallel-plate capacitor. The other two capacitor electrodes are concentric rectangular patches of aluminum, about 0.3 μm-thick, on the bottom of the hole; the inner patch serves as the driving electrode, while the outer one serves as the sensing electrode, as explained below. Vent holes (not shown in the figure) between the hole and the outside prevent spurious deflection of the diaphragm by changes in ambient air pressure.

In use, the upper (outer) surface of the diaphragm and the rest of the doped silicon wafer is mounted flush with an aircraft or other surface of interest. A dc po-

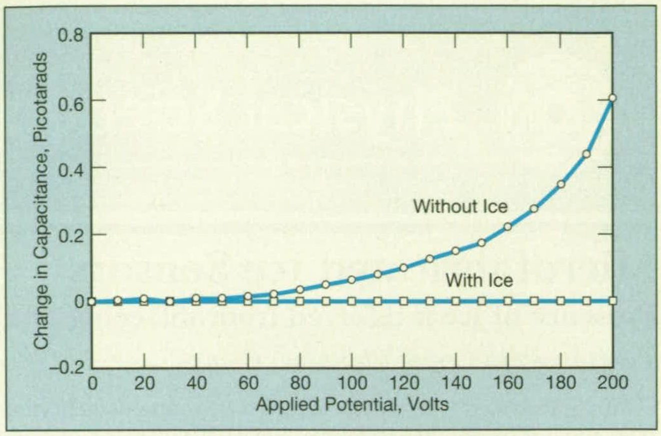



Figure 2. The **Change in Capacitance** as a function of driving voltage was measured in an experiment on a prototype device, with and without ice on the outer surface. In this device, the diaphragm was square, 1 mm on a side.

tential is applied between the driving electrode and the diaphragm to deflect the diaphragm slightly into the hole by electrostatic attraction. The amount of deflection is inferred from the change in capacitance between the diaphragm and the sensing unit; for this purpose, the diaphragm and sensing electrode are connected as the terminals of an input capacitor in a frequency-modulation circuit with a nominal frequency of 48 MHz, and the change in capacitance is determined from the change in frequency.

A deposit of ice on the outer diaphragm surface stiffens the diaphragm, reducing the deflection and thus the change in capacitance for a given driving voltage (see Figure 2). The presence of ice can thus be inferred from the reduction in the change in capacitance for a given applied potential.

Future versions of these devices may afford the capability to determine the thickness of ice according to the following principle: The diaphragm would be designed to vibrate at a suitable resonance frequency. In operation, the resonance would be excited and its frequency measured, and the thickness of ice would be determined from any deviation from a nominal (no-ice) resonance frequency.

*This work was done by Russell G. DeAnna of the U. S. Army Research Laboratory and Mehran Mehregany and Shuvo Roy of Case Western Reserve University for* **Lewis Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*

*Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7–3, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16633.*

# Methanol-Fuel-Cell Biplate Improved for Removal of Water

## Low-pressure airflow from an ordinary fan is sufficient.

*NASA's Jet Propulsion Laboratory, Pasadena, California*

An improved design for a biplate in a methanol fuel cell provides increased efficiency in the removal of water, relative to older designs. For reasons explained below, this design both improves the performance of the fuel cell and increases the overall energy efficiency of the power-generating system of which the fuel cell is a part.

A typical methanol fuel cell includes a number of membrane/electrode assemblies (MEAs) stacked in alternation with

biplates. Each biplate serves partly as an electrical contact between the cathode of the MEA on one side and the anode of the MEA on the other side. The biplate also contains channels for circulating air past the cathode and other channels for delivering fuel (methanol) to the anode.

During operation of the fuel cell, several parasitic chemical and physical effects cause water to accumulate in the air channels. If the water is not removed, then it impedes airflow in the channels, and consequently, the fuel-cell performance deteriorates. In the cases of most older biplate designs, considerable power is expended to supply pressurized air to blow the water out of the air channels; as a result, overall energy efficiency is reduced. The energy-efficiency issue becomes even more important if the fuel cell is operated at room temperature (about 25 °C, in contrast to a typical higher operating temperature of about 95 °C) because the fuel-cell output deceases with decreasing temperature in this range.

The improved biplate is designed to exploit gravitation and surface tension to remove water without need to supply pressurized air. It is still necessary to bring in air for the electrochemical reaction in the fuel cell, but the improved biplate offers little resistance to airflow, so that a low-power fan that supplies air at slightly more than atmospheric pressure is sufficient. Thus, a high level of performance can be maintained, and energy efficiency is enhanced.

To enable gravitation to drain water from the fuel cell, the airflow channels in the improved biplate are oriented vertically, with inlets at the top and outlets at the bottom (see figure). Most of the biplate is made of a graphite/epoxy composite material, which is hydrophobic. Unfortunately, hydrophobic surfaces tend to impede drainage. Therefore, the drainage surfaces of the biplate are treated to make them hydrophilic, so that immediately upon release at the cathode, a drop of water becomes part of a surface layer of water that drains to the bottom of the biplate. The treatment to make the surfaces hydrophilic includes coating with a commercial perfluorosulfonic acid-based ion-exchange polymer followed by coating with a carbon-supported platinum/ruthenium catalyst. The combination of coating materials was chosen because it is chemically compatible with other fuel-cell materials and is expected to be chemically stable in the long term.

If nothing were done to prevent it, surface-tension effects could cause an air-outlet port at the bottom of the biplate to become plugged with water. Two features prevent this from happening: (1) the port is made large enough that water cannot straddle it and (2) a metal insert extending from the edge of the biplate wicks the water away from the port. At the edge of the insert, water forms into drops, which then fall off.

To minimize resistance to airflow, air is supplied to the biplate via a large external manifold. The air passes from the manifold into the biplate through a large inlet port (equal in size to the outlet port). The air channels in the biplate are also made large to minimize resistance to flow.

*This work was done by Andrew Kindler and Albany Lee of Caltech for* **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*

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*Refer to NPO-20308, volume and number of this* NASA Tech Briefs *issue, and the page number.*

# Localization by Maximum-Likelihood Matching of Range Maps

**This technique is intended for use in autonomous navigation of robotic vehicles.**

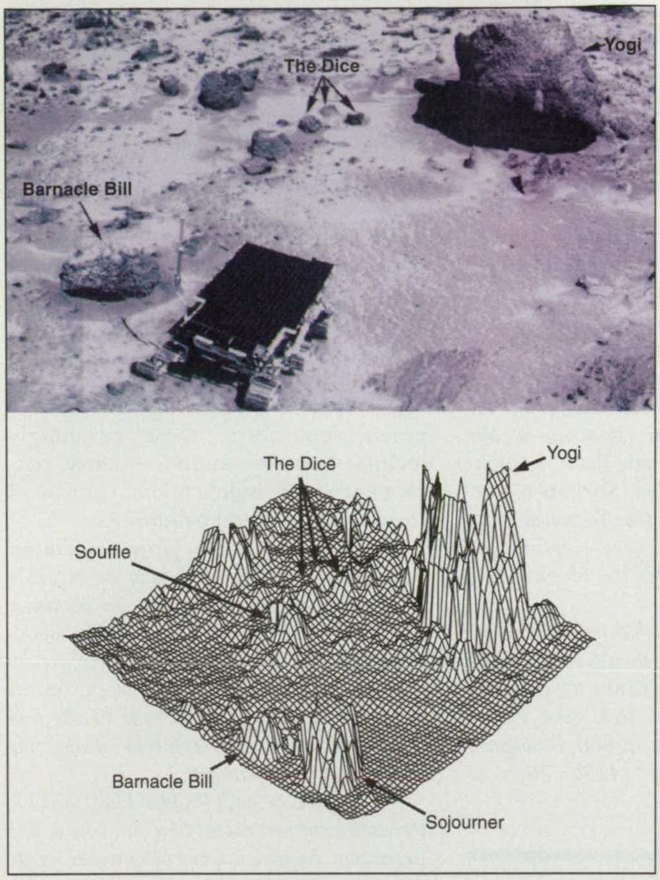
*NASA's Jet Propulsion Laboratory, Pasadena, California*

A procedure for determining the location of an instrumentation platform on natural terrain is based on a concept of maximum-likelihood matching of two range maps: (1) a local range map generated by processing of images of the terrain in the immediate vicinity acquired by stereoscopic video cameras mounted on the platform and (2) a previously generated range map of a larger surrounding terrain area (a "global" map) in a known frame of reference. The procedure, which is still undergoing testing and refinement, was developed primarily to aid the autonomous navigation of exploratory robotic vehicles on distant planets. The procedure might also be adaptable to similar applications on Earth and to such related applications as enabling blind persons to determine their locations in previously mapped natural and artificial environments.

Once the local range map has been computed from the stereoscopic imagery, it is converted to a volume-cell (voxel) representation (see figure). Optionally, if the orientation of the robotic vehicle or other instrumentation platform is known from a gyrocompass, Sun sensor, or other independent sensor, then the conversion to the voxel representation can include rotation into the orientation of the global map to facilitate matching.

The range points in the local map are binned in a three-dimensional occupancy map of the surroundings at some specified scale. In a subprocess that amounts to high-pass filtering of vertical-position data, the local average of the terrain height is subtracted from each cell; this subprocess is not strictly necessary and it reduces the ability to determine changes in the height of the platform, but, advantageously, it reduces the computation time needed for localization by eliminating the need to search over vertical translations. Each cell in the occupancy map is said to be occupied or unoccupied, according to whether it contains or does not contain, respectively, a range pixel.

The degree of matching between the global map and the local occupancy map is quantified by use of conventional image-matching measure based on the Hausdorff distance and reformulated in probabilistic terms accord-




A **Three-Dimensional Local Map** of the local terrain was generated from images acquired by stereoscopic cameras in the *Sojourner* vehicle. In a test of the procedure described in the text of this article, the local map was then matched with a "global" map generated from images acquired by stereoscopic cameras in the Mars *Pathfinder* lander, from which the *Sojourner* had been deployed.

ing to the principle of maximum-likelihood estimation. The likelihood function is given by

$$L(X) = \prod_{i=1}^{n} p(D_i; X),$$

where $D_i$ is the distance from the $i$th occupied voxel in the local map to the closest voxel in the global map, $X$ is the trial position of the local map relative to the global map, $p(D_i,X)$ is a probability distribution function (PDF), and $n$ is the number of occupied voxels. To some extent, the PDF can be chosen arbitrarily: One suitable choice is a simple two-value PDF that yields a measure equivalent to the Hausdorff fraction commonly used in matching images; a better (albeit more complex) choice is a normal distribution function with an additive term.

The most likely position of the local map relative to the global map [that is, the position, $X$, that maximizes $L(X)$] is taken to be the position of the platform. The search for this position can be started from a position that has been either assumed or estimated by an independent navigation technique. The estimate of position is then progressively refined by use of efficient search techniques that provide for the recursive division of the search space into smaller cells and pruning of cells that cannot contain a position superior to the best known position.

*This work was done by Clark F. Olson of Caltech for* **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Information Sciences category.*
*NPO-20392*

# Books & Reports

## Study of DLS Monitoring of the Growth of Protein Crystals

A report describes an experimental study of whether an advanced fiber-optic dynamic-light-scattering (DLS) probe affords a capability for noncontact detection of particles of various sizes associated with the stages of growth of protein crystals in automated hanging-drop protein-growth apparatuses. [A related previous report was described in "DLS Sizing of Particles in Hanging Liquid Drops" (LEW-16515), *NASA Tech Briefs*, Vol. 21, No. 12 (December 1997), page 98.] The DLS probe used in this study was a modified version of the one described in "Compact, Noncontact Fiber-Optic Probe for Diagnosis of Eye Diseases" (LEW-16429), *NASA Tech Briefs*, Vol. 22, No. 2 (February 1998), page 82, and was augmented with a miniature microscope for viewing protein crystals.

*This work was done by Rafat R. Ansari of Case Western Reserve University; Kwang I. Suh of the National Research Council; Lawrence J. DeLucas, Alireza Arabshahi, and Terry L. Bray of the University of Alabama at Birmingham; and W. William Wilson of Mississippi State University for* **Lewis Research Center**. *To obtain a copy of the report, "A Fiber Optic Probe for Monitoring Protein Aggregation, Nucleation, and Crystallization," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*

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## Mars Lander

A brief report presents drawings for the conceptual design of a spacecraft that would land on Mars or another remote planet. The spacecraft would have a tetrahedral shape, would include airbags to cushion impact, and would have a self-righting capability. The drawings show the general appearance of the spacecraft and show the outlines and locations of some power, propulsion, temperature-regulation, and communication equipment. This design presents significant licensing opportunities in the toy and model industries.

*This work was done by Tommaso P. Rivellini, Robert Bamford, Jim Hendrickson, and Mike O'Neal of Caltech for* **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Machinery/Automation category.*
*NPO-19859*

## Development of Circuitry for Wristband Radio Transponders

A document proposes the development of several alternative types of electronic circuits for wristband transponders for the system described in "Person-Locator System Based on Wristband Radio Transponders" (NPO-19280) *NASA Tech Briefs*, Vol. 19, No. 12 (December 1995), page 40. To recapitulate: microscopic transponder circuits embedded in wristbands would be powered by modulated signals radiated by transceiver nodes and would respond by transmitting signals modulated with unique digital codes to identify the wearers. The document includes a brief discussion of the advantages of the current mode in the proposed application; these advantages include superior high-frequency performance and independent control of closed-loop gain and bandwidth.

*This work was done by Victor Boyadzhyan and Frederick Mintz of Caltech for* **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the document, "Passive RF Transponder and Other RF Circuitry Implemented by Current Mode Enabling Technology," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Systems category.*

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## Sorption Compressor for Collecting Atmospheric $CO_2$ on Mars

A report describes a small, lightweight sorption compressor that is now undergoing development for use in collecting $CO_2$ from the atmosphere on Mars. This compressor would be part of a system that would use the $CO_2$ to generate oxygen and a carbon-based fuel for a spacecraft to return specimens to Earth. Unlike mechanical compressors, a sorption compressor has few moving parts and thus has potential for greater reliability.

*This work was done by Donald Rapp and Paul Karlmann of the California Institute of Technology for* **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Adsorption Compressor for Acquisition and Compression of Atmospheric $CO_2$ on Mars," access the Technical Support Package (TSP)* ***free on-line at www. nasatech.com*** *under the Machinery/Automation category.*
*NPO-20353*

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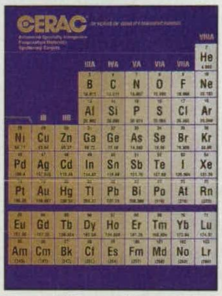


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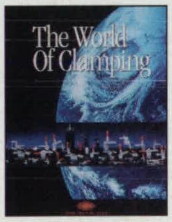


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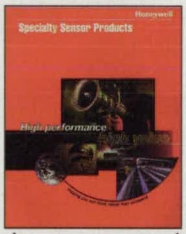


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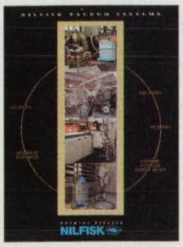


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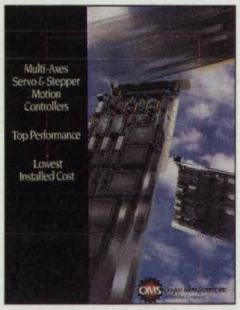


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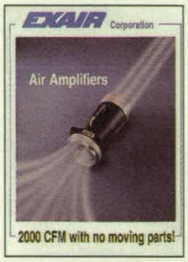


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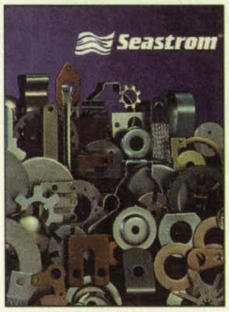


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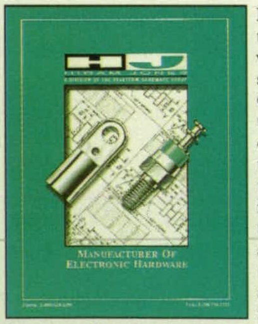


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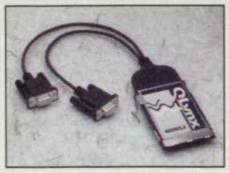

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How About You? Quatech's DSP-200/300 is part of the Ground Test Equipment at NASA's Johnson Space Center. The dual port RS-422/485 serial adapter is used to perform verification testing on GPS receivers. It is used for multiple applications on the Space Shuttle as well. Whatever your application, Quatech can provide the solution. Our serial PCMCIA adapters are available for RS-232 & RS-422/485 with 1, 2, or 4 ports. For more information call 1-800-553-1170, or visit our website: http://www.quatech.com

**Quatech, Inc.**

**For More Information Circle No. 656**

## BURST PRESSURE TEST SYSTEM

APP's Automated Burst Pressure Test System is designed to determine exact pressure at which materials burst or fail. Applications include: burst pressure of disks or pressure vessels, crushing point of materials, crimp or vent failure of battery casings, and fatigue cycling. The automated testing method uses high-speed, high-accuracy processing and control algorithms to determine leak or burst pressure. Pressures up to 60,000 PSI are possible. Accuracy of results is within ±.25% of full scale and resolution is within ±.01% of full scale. Advanced Pressure Products, 83 Brown Rd., Ithaca, NY 14850; Tel: 607-257-5544 or 800-APP-VALV; Fax: 607-257-5639; E-mail: info@pmiapp.com; URL: http://www.pmiapp.com.

**Advanced Pressure Products**

**For More Information Circle No. 657**


## POROSITY TESTING SERVICES

In addition to porosity-testing instrumentation, PMI provides a wide variety of porosity tests including: pore size distribution; gas and liquid permeability; capillary flow; surface area; filter integrity; diffusion permeability; microflow analysis; Frazier permeability; and more. PMI Porometers, Windows-based Envelope Surface Area Analyzers, and other instruments are available for sale, lease, or rent. Porous Materials, Inc., 83 Brown Rd., Ithaca, NY 14850; Tel: 800-TALK-PMI or 607-257-5544; Fax: 607-257-5639; www.pmiapp.com

**Porous Materials, Inc.**

**For More Information Circle No. 658**


## NEW CATALOG FROM LOVE CONTROLS

Love Controls' new full-color, 108-page 1999 Catalog shows the company's latest products. Features include the world's first and only dual-display 1/32 DIN temperature/process control, thermocouples, and RTDs; power controls, indicators, recorders, and data-acquisition products. Love Controls Division, Dwyer Instruments, Inc., PO Box 338, Michigan City, IN 46361-0338; Tel: 219-879-8000; Fax: 219-872-9057; love@love-controls.com; www.love-controls.com

**Love Controls Division, Dwyer Instruments, Inc.**

**For More Information Circle No. 659**


## MECHANICAL EVENT SIMULATION (MES) SOFTWARE

Algor's Accupak/VE MES software replicates real-world behavior of a mechanical design having motion and impact. Accupak/VE gives stresses over time using known physical data, not assumed forces. Engineers can view events as they unfold. To see a replay of this car-suspension analysis and other analysis replays, visit Algor's home page or order your FREE CD-ROM. Tel: 412-967-2700; Fax: 412-967-2781; e-mail: info@algor.com; www.algor.com

**Algor, Inc.**

**For More Information Circle No. 660**

## PORTABLE ROCKWELL TESTER

The new direct readout EquoStat tester has been developed for testing small or thin parts in the thickness range of .08" to 1.0". The hardness value HRZ can be converted to other hardness values (HV; HRC; HB; HR15N,) by pressing a key. West-Met Instruments, Inc., P.O. Box 1145, 936 Maple Street, Edmonds, WA 98020. Tel: 425-771-1292, 800-446-5670; Fax: 425-771-1722.

**West-Met Instruments, Inc.**

**For More Information Circle No. 661**

## BALINIT® C TUNGSTEN CARBIDE/CARBON

Balzers Tool Coating offers new literature on Balinit® C Tungsten Carbide/Carbon (WC/C) composite coating. It provides comprehensive information on Balzers' WC/C coating, which is ideal for use in applications such as diesel fuel components, textile machinery drives, machine tools, aircraft gears, racing engines, and planetary drives in construction machinery and commercial vehicles. WC/C also is beneficial in dry machining and plastic molding operations. For more information on Balinit® C Tungsten Carbide/Carbon, contact Balzers Tool Coating Inc. at 661 Erie Ave., North Tonawanda, NY 14120. Tel: 716-693-8557; Fax: 716-695-1995

**Balzers Tool Coating Inc.**

**For More Information Circle No. 662**


## WAVE/COMPRESSION SPRING CATALOG

Just updated, Catalog #WS-93A contains hundreds of NEW stock sizes of wave/compression springs available from stock, including spring design formulas, materials guide, and typical applications. This 40-page engineering/parts manual describes Smalley's exclusive edgewinding manufacturing process. SPECIAL SPRINGS ARE EASY TOO! Smalley springs, available from 3/8" to 84" in diameter, are produced by circle-coiling flat wire to exact specifications involving no dies or special tooling charges. Smalley Steel Ring Co., 385 Gilman Ave., Wheeling, IL 60090; Tel: 847-537-7600; Fax: 847-537-7698; http://www.ringspring.com.

**Smalley Steel Ring Co.**

**For More Information Circle No. 663**

## VACUUM PUMP VIBRATION ISOLATORS

The NEC vibration isolators effectively remove turbo-molecular and cryo-pump vibrations. Two models are available in elastomer and air-isolated versions. They are UHV compatible, have short insertion lengths, and high conductance. A wide variety of flanges are available. National Electrostatics Corp., 7540 Graber Rd., Box 620310, Middleton, WI 53562-0310; Tel: 608-831-7600; Fax: 608-256-4103; http://www.pelletron.com

**National Electrostatics Corp.**

**For More Information Circle No. 664**

## VLSI INTERCONNECTION SPECIALISTS

Ironwood Electronics produces a range of interconnect solutions including hundreds of prototyping adapters, test probe adapters, programming adapters, and other interconnect devices. For fully compliant surface mount interconnect test adapters, we offer a wide selection of high-quality solutions. We also have custom design services for unique solutions in packaging. Ironwood Electronics, PO Box 21151, St. Paul, MN 55121; Tel: 651-452-8100; Fax: 651-452-8400; www.ironwoodelectronics.com

**Ironwood Electronics**

**For More Information Circle No. 665**


## STATIC ELIMINATORS

EXAIR-Ionizers remove static and dust in many applications and contain no radioactive element. Air-delivered ions neutralize static and clean surfaces up to 20 feet away. Three styles include ionizing air knife, air cannon, and hand-held air gun. Applications include web cleaning, pre-paint auto-body blowoff, and neutralizing plastic parts. EXAIR Corporation, 1250 Century Circle North, Cincinnati, OH, 45246. Tel: 800-903-9247; Fax: 513-671-3363; e-mail techelp@exair.com; www.exair.com

**EXAIR Corporation**

**For More Information Circle No. 666**

## ELECTRONIC HARDWARE

Globe Electronic Hardware, Inc. introduces its latest 260-page catalog, which provides complete engineering dimensions and specifications for our entire line of precision electronic hardware. Products include: Standoffs, Spacers, Captive Panel Screws, Retainers, Handles, Ferrules, and other quality components in both American and METRIC standards. Globe Electronic Hardware, Inc.; Tel: 800-221-1505; Fax: 718-457-7493; www.globelectronics.com

**Globe Electronic Hardware, Inc.**

**For More Information Circle No. 667**


## FREE TEST SOLUTION CATALOG

New, free, 64-page 1998 PC-Based Test Solution Source Book from Geotest (Marvin Test Systems, Inc.). Features over 100 PC-based products for ATE, data acquisition, and test & measurement applications. New products featured include: GT50-DIO dynamic digital I/O, NT5000 ROM Emulator, GT40-RFS 200MHz Multiplexer, GT614-SM high density switch matrix, GTXI instrumentation chassis, and more. Call for your free copy. Geotest/Marvin Test Systems, Inc.; Tel: 888-TEST-BY-PC (837-8297) or 714-263-2222; www.geotestinc.com

**Geotest/Marvin Test Systems, Inc.**

**For More Information Circle No. 668**


## INTERNALLY GAGED FORCE TRANSDUCERS

Catalogs describe a complete line of force transducers manufactured by Strainsert. Transducers include: flat load cells, tension and compression from 250 to 2 million pounds; clevis pins with 0-10 vdc and 4-20 ma outputs; tension links up to 400,000 pounds; load-sensing bolts and studs; and load indicators. "Special" designs are invited. Strainsert, Union Hill Industrial Park, West Conshohocken, PA 19428; Tel: 610-825-3310; Fax: 610-825-1734.

**Strainsert**

**For More Information Circle No. 669**


## FREE DESIGN AID

Save layout time and eliminate detailing with this 16 page Template catalog. This catalog shows FULL SIZE drawings of many tooling components used in designing jigs and fixtures. It includes Spring & Ball Plungers, Nuts, Bolts, Washers, Knobs and many other items, all with sizes and part numbers. Also included will be a copy of the current catalog listing these and additional items, along with prices. Northwestern Tools, Inc., 3130 Valleywood Drive, Dayton, OH 45429; Tel: 937-298-9994; Fax: 937-298-3715.

**Northwestern Tools, Inc.**

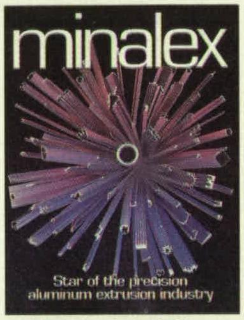
**For More Information Circle No. 670**


## INSTRUMENT DATA ACQUISITION

The SoftwareWedge™ directs serial (RS-232, RS-485, RS-422) data from any instrument into any Windows 3.x, 95, or NT application such as Excel, MMIs, VB, Control, and Statistical applications. This configurable driver provides full data acquisition and control of PLCs, data loggers, scales, flow meters, lab instruments, etc. Please contact TAL Technologies, Inc., 2027 Wallace St., Philadelphia, PA 19130; Tel: 800-722-6004 or 215-763-7900; Fax: 215-763-9711; http://www.taltech.com

**TAL Technologies, Inc.**

**For More Information Circle No. 671**




## PRECISION ALUMINUM EXTRUSIONS

New! An informative brochure from MINALEX, leader in close tolerance shapes to 3 1/2", illustrates typical applications and describes capabilities including short runs. MINALEX, quality leader, delivers on time, every time. MINALEX, PO Box 247, Whitehouse Station, NJ 08889; Tel: 908-534-4044; Fax: 908-534-6788.

**Minalex**

**For More Information Circle No. 672**


## FREE FULL-LINE DATA ACQUISITION CATALOG

DATEL SYSTEMS' new 224-page, 1999 full-line catalog offers a wide range of high-speed, high-performance and multi-function Data Acquisition boards. These boards feature on-board DSP co-processors, FIFO memory, and more. Included are advanced performance boards for PCI, ISA, and VME bus. For a FREE copy of the 1999 catalog or for additional product information contact: DATEL SYSTEMS, 11 Cabot Blvd., Mansfield, MA 02048-1151; Tel: 800-233-2765; Fax: 508-339-6356; e-mail: sales@datel.com; www.datel.com

**Datel Systems**

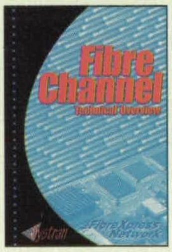
**For More Information Circle No. 673**


## LIQUID NITROGEN CONTROLLERS & PROBES

Teragon offers $LN_2$ sensors, level transducers, level controllers, and complete auto-fill systems. Features include digital displays, current and voltage outputs, alarms, RS232, and transfer hardware. Designed for the user, these level solutions are economical, reliable, and easy to install. Teragon Research, San Francisco, CA; Tel: 415-664-6814; Fax: 415-664-6745; www.trgn.com

**Teragon Research**

**For More Information Circle No. 674**




## NETWORK FOR DSP APPLICATIONS

Introducing FibreXpress®, SYSTRAN Corp.'s new line of Fibre Channel host bus adapters. FibreXpress is ideal for very-high-speed mass storage and high-throughput, data-intensive DSP applications such as radar, sonar, medical scanners, and OCR. Request your free tech overview today! SYSTRAN Corp.; Tel: 937-252-5601; Sales: 800-252-5601; Fax: 937-258-2729; e-mail: info@systran.com; WWW: http://www.systran.com

**SYSTRAN Corp.**

**For More Information Circle No. 675**


## ALL-NEW DEMO IN LATEST VIDEO/CD

Learn more about Algor's Mechanical Event Simulation (MES) software with this free video. See a new impact force demo, and other real-world experiments as compared to results from Algor's Accupak/VE MES for Virtual Prototyping with Linear and Nonlinear Stress Analysis software. CD includes a version of Algor's web site with software you can try. Address: 150 Beta Dr., Pittsburgh, PA 15238; Tel: +1 (412) 967-2700; Fax: +1 (412) 967-2781; info@algor.com; www.algor.com

**Algor, Inc**

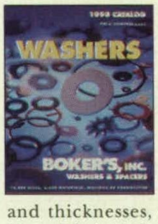
**For More Information Circle No. 676**

## OMEGA'S TEMPERATURE HANDBOOK™ 21ST CENTURY™ PREVIEW EDITION

OMEGA Engineering, Inc. announces the release of The Temperature Handbook™ 21st Century™ Preview Edition. This informative, hard-bound limited edition includes a larger selection of infrared temperature-measurement instrumentation and reference material, valuable technical articles, and a detailed index. OMEGA Engineering, Inc., One Omega Dr., Stamford, CT 06907-4047; Tel: 203-359-1660; 1-800-TC-OMEGA; Fax: 203-359-7700; e-mail: info@omega.com; www.omega.com

**OMEGA Engineering, Inc.**

**For More Information Circle No. 677**




## WASHERS AND SPACERS!

Boker's FREE, 40-page 1998 Catalog offers over 14,000 non-standard sizes with no tool charges. Included are outside diameters of 0.080" to 2.631", a wide variety of inside diameters and thicknesses, and 2,000 material variations. Materials include low carbon steel sheet, spring steel, stainless steel, aluminum, brass, copper, and nickel silver. Also featured are non-metallic washers such as Delrin®, Teflon®, Mylar®, and nylon. Metric sizes are also available. Boker's, Inc., 3104 Snelling Ave., Minneapolis, MN 55406-1937; Tel: 800-927-4377; Fax: 612-729-8910; http://bokers.com

**Boker's, Inc.**

**For More Information Circle No. 678**


## VAST VARIETY OF KNOBS AND HANDLES

DIMCO-GRAY™'s new catalog features a wide variety of knobs and handles in thermoset, thermoplastic, and Dimco-Grip™ — "the ultimate finishing touch"™ for molded parts and products. The catalog includes actual-size photos of our stock products. START working with an owner, contact: DIMCO-GRAY Co.; 8200 S. Suburban Rd.; Centerville, OH 45458-2709; Tel: 937-433-7600; Fax: 937-433-0520; Toll-Free: 800-876-8353; e-mail: sales@dimco-gray.com; www.dimco-gray.com

**DIMCO-GRAY Co.**

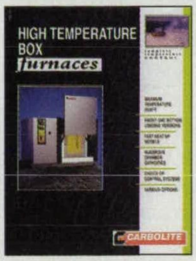
**For More Information Circle No. 679**


## PRECISION LC FILTERS

The new PRECISION LC FILTER catalog is a design and specification guide for all types of LC FILTERS. By reading "Filter Facts" you will gain a good general understanding of LC FILTERS and some of their applications. The new catalog includes specifications on standard and custom-designed lowpass, highpass, bandpass, band reject, and NTSC video filters. Allen Avionics, Inc.; 224 East Second St., Mineola, NY 11501; Tel: 516-248-8080; Fax: 516-747-6724

**Allen Avionics, Inc.**

**For More Information Circle No. 680**




## BOX FURNACES TO 2050 °C

Carbolite's high-temperature box furnaces set new standards in performance, safety, and build quality. The line includes a wide choice of economical SiC heated models (1400/1500/1600 °C), regular front and bottom loading models (1700/1800 °C), and ultra high-temp models (2050 °C) with many optional features. Carbolite Inc.; P.O. Box 7; 110 S. 2nd St.; Watertown, WI 53094; Tel: 920-262-0240; Fax: 920-262-0255; e-mail: sales@carbolite.com

**Carbolite Inc.**

**For More Information Circle No. 681**

## New T-Shirts!


**Solar System**
Dramatic full-color illustration of the planets on high-quality black cotton shirt.

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Celebrate history in the making! This white cotton shirt features the official emblems from Glenn's first voyage on Mercury 6 in 1962 and his return to space this fall aboard the Shuttle Discovery.

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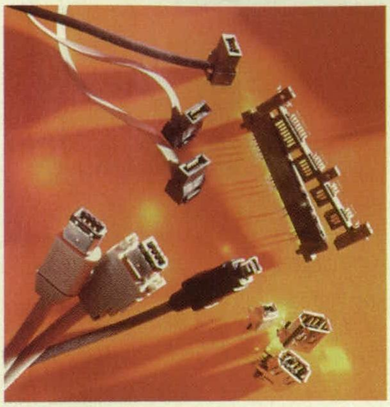
**For More Information Circle No. 455**

# New on the MARKET

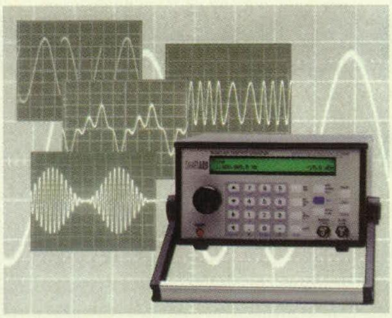
## Serial I/O Connectors



Molex, Lisle, IL, offers a line of serial I/O connectors that meet the requirements of the IEEE 1394 standard. The connectors feature full metal shielding for ESD protection, and gold-plated leaf contacts that withstand up to 1,500 cycles. A polarized shell design and friction lock grounding fingers ensure plug retention. Made of high-temperature plastic, the connectors can withstand SMT or SMT-compatible soldering processes. The six-circuit connector includes right-angle, upright thru-hole, and ring-angle SMT flat PCB sockets and cable assembly plugs in 0.7-, 2.0-, and 4.5-meter lengths. The SMT version includes positioning pegs for PCB alignment and stability. **Circle No. 710**

## Arbitrary Waveform Generator

The BNC Model 625A Smart ARB arbitrary waveform generator from Berkeley Nucleonics Corp., San Rafael, CA, provides function, arbitrary waveform and pulse generation capabilities. Modes include AM, FM, PM, SSB, FSK, BPSK signal modulation, DTMF generate, DTMF detect, voltage and power measurement, and data and word generation. It also includes the standard sine, square, ramp, triangle, and random waveforms. **Circle No. 728**



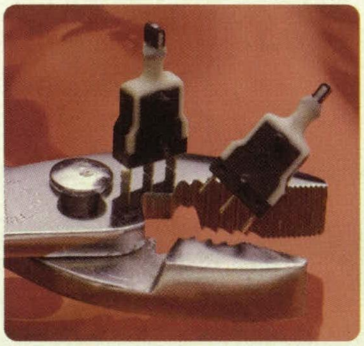
## Computer Monitors

The V75 and V73 monitors from Optiquest, Walnut, CA, have a 16" viewable screen. The V75 features an ultra-bright CRT with a 0.26-mm super-fine dot pitch for sharp images to a resolution of 1600 x 1200. It also offers a 77-Hz refresh at 1600 x 1200 for flicker-free performance. The V73 offers a maximum resolution of 1280 x 1026, a 0.26-mm dot pitch, and an 87-Hz refresh rate at 1024 x 768 resolution. The monitor includes a SuperContrast™ screen treatment for realistic color and improved clarity. An anti-reflection, anti-glare ARAG® screen treatment reduces glare. Both monitors also feature the menu-driven OnView® system that enables users to adjust images for brightness, contrast, pincushion, and trapezoid with one button. **Circle No. 734**

## Recording Thermometer

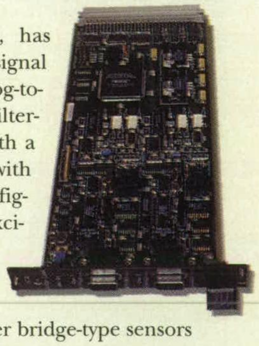
The Fluke Hydra Series II 2620T and 2635T recording thermometer systems from Fluke Corp., Everett, WA, consist of a Hydra Series II data logger and a precision SPRT (platinum RTD probe) that are calibrated together as a system. The 2620T can be used as a bench-style monitor or connected to a computer (with optional software) to capture real-time data and track measurement trends. The 2635T can be operated as a standalone unit that records measurements over a long period, and writes them to an internal memory card. Both units can calibrate up to 18 thermocouples at once. Other features include a 21-channel universal input connection, removable PCMCIA card for increased data storage, and single-point accuracy of 0.015°C. **Circle No. 730**

## Compact Double-Pole Switch



A double-pole switch offered by SAIA-Burgess Electronics, Buffalo Grove, IL, is electrically off when the actuator is in the middle position; it switches to one of two different control circuits when the actuator is moved to the left position, and to the other control circuit when in the right position. The switch has a nominal electrical rating of 14 VDC, 2 amp maximum. It is fully sealed and is produced using twin-shot injection molding. The switch uses no adhesives, and consists of two principal components — the main body, which has an actuator knob, gaiter, and sealing; and the base, which consists of metal terminal pins, central terminal and contact mechanism support, switch mechanism, and actuating plunger. **Circle No. 727**

## Bridge Signal Conditioner



KineticSystems Corp., Lockport, IL, has introduced the SC20 two-channel bridge signal conditioner that works with existing analog-to-digital converters that include gain and filtering. Setup and control are performed with a standard serial port, allowing it to work with VME, VXI, and other proprietary bus configurations. Features include per-channel excitation, bridge balancing, shunt calibration, and full programmability of the bridge. The unit is packaged in a 5.25 x 8.7" module. Strain gages, RTDs, and other bridge-type sensors can be accommodated. **Circle No. 729**

## Data Acquisition for CompactPCI

Analogic Corp., Peabody, MA, has introduced the CPCI-14-1 high-speed, dual-channel analog input board for CompactPCI®. Packaged in a 3U Eurocard form factor, the 14-bit board provides high signal-to-

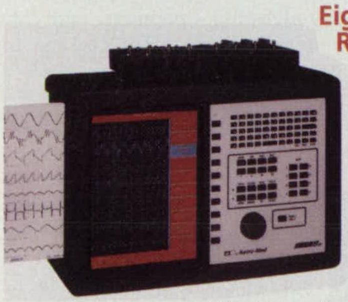
noise ratio and spurious-free dynamic range at sampling frequencies from 1 to 10 MHz within a 0 to 70°C range. The card is installed vertically in a protective card cage, and includes a DSP Link Port that can provide a direct interface to a SHARC®-based DSP board. The board enables performance levels of 75 dB SNR and 90 dB SFDR with input signals to 5 MHz. **Circle No. 725**


## Low-Profile Keypad

Computer Keyboard Systems, Santa Monica, CA, offers the Series 42D rugged, restrictive-function keypad with a 24x2 transflective LCD backlit display. The unit is available cased, uncased, or with a front-mount bezel. The front surface is resistant to wear and chemicals, and is sealed to NEMA 4 standards. The front overlay, key coding, keypad interfaces, and labels for all 42 keys can be customized with standard inserts. It features RS-232 or RS-485 interfaces with up to two additional RS-232 ports for local control of bar code readers or printers. The keypad has on-board 32K of ROM or 64K of RAM for standard display messages, printer report format, and process control. **Circle No. 732**

## Urethane Adhesives


Loctite Corp., Rocky Hill, CT, has introduced Durabond 605FL and 610FL industrial-grade urethane adhesives for structural bonding applications. Once mixed, the two-component adhesives set at room temperature to form flexible bond lines. Durabond 605FL is of medium viscosity and bonds a variety of metals, plastics, glass, wood, and other substrates. Low-viscosity Durabond 610FL bonds polycarbonate, butyrate, and other plastics, in addition to wood, glass, and metal. The products are available in self-mixing 50-, 200-, and 400-ml dual cartridges for use with manual or pneumatic dispensers. **Circle No. 733**

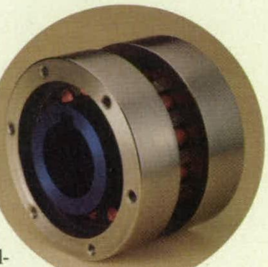


## Eight-Channel Field Recorder

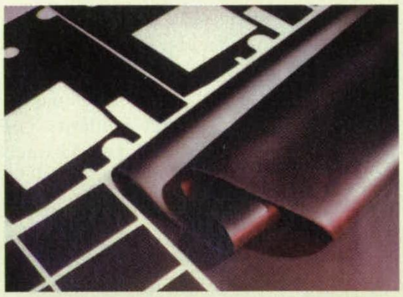
Astro-Med, West Warwick, RI, offers the Dash 8u field recorder that displays and records eight channels of real-time data at frequencies to 2 kHz. Its universal inputs accept single-ended and differential voltages, thermocouples, pressure transducers, and load cells. Others features include a 10.4" active color LCD monitor, internal 2-Gb hard drive, DSP for programmable filtering, and a built-in 100-Mb removable Zip™ drive for data transfer, archiving, and test setups. The system features a sample capture rate of 0.2 Hz to 20 kHz per channel, and can store up to 800 million samples. **Circle No. 726**

# New on the MARKET

## Higher-Torque Clutches



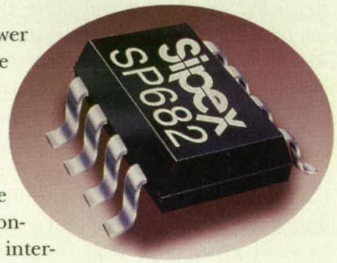
The Hilliard Corp., Elmira, NY, has introduced Magna Torque overrunning clutches that provide operating speeds in excess of 3600 RPM using a wedge ramp design, which combines roller ramp, sprag, and wrap spring model features. Applications include dual drives, backstopping, suspended conveyors, and gearboxes. The clutches are available in various configurations to interchange with other brands. **Circle No. 736**



## Shock-Damping Foam

Polymer Technologies, Newark, DE, offers Polydamp® Energy foam, an open, microcellular vinyl foam specifically formulated to damp shock and vibration energy over a broad temperature and frequency range. The foam is 3/32" thick and can be used as a gasket for components that need to be both sealed and isolated from transmitted shock and vibration. Applications include protecting instruments and gauges on panels or instrument arrays, in equipment enclosures, and in place of conventional gasketing materials. **Circle No. 738**

## Voltage Doubler




The SP682 monolithic, low-power inverting, charge pump voltage converter from Sipex Corp., Billerica, MA, produces a doubled, negative voltage from a single positive supply. Three external charge pump capacitors are required to support the voltage conversion and doubling process. An internal oscillator generates a 12-kHz clock, which cycles the internal switching that charges the storage and transfer capacitors. The unit is designed for low power applications requiring a typical +3V battery source such as a lithium cell. Applications for the charge pump include battery-operated systems, portable equipment, handheld instruments, notebook and laptop computers, and data acquisition systems. The devices come in 8-pin plastic DIP packages or 8-pin SOIC packages. **Circle No. 737**

## Rugged Computer System

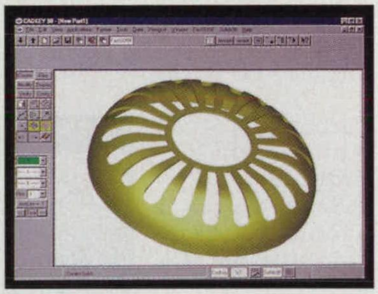
The RCS 5100 rugged computer system from Greco Systems, El Cajon, CA, is a rack-mount industrialized computer with hot-swappable fans that can be replaced without shutting down the system. The computer includes one 3-1/2" and two 5-1/4" drive bays and can accommodate a CD-ROM. It features a positive airflow and exhaust system. Drive bays are shock-insulated and ventilated. The computer has a standard 315-watt power supply and is Pentium-upgradable. **Circle No. 731**

# New on DISK

## Advanced Technical Computing

Mathcad 8 Professional technical calculation and analytical software from Mathsoft, Cambridge, MA, is designed for engineers, scientists, and other technical professionals. New features include solver and optimization capabilities, Workstation-level OpenGL graphing, new chart annotating capabilities, and a variety of formatting options. IntelliMath™ features, such as QuickPlot Wizard, AutoSelect, and SmartUnits, automate various routines and provide "recipes" and hints. Editing, header/footer, and document-control features are designed to improve formatting and document preparation. Enhanced 3D graphing, communication, collaboration, and documentation tools support information-sharing. Expanded OLE support and component architecture allow the program to integrate seamlessly with any desktop or engineering application. **Circle No. 752**

## Mechanical PC-CAD Solution

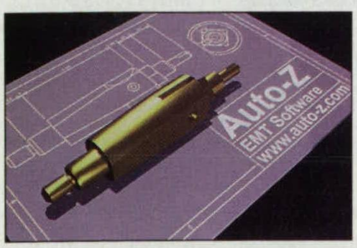


CADKEY® 98 mechanical CAD software from Baystate Technologies, Marlborough, MA, includes the integration of FastSOLID™ advanced solid-modeling technology. Other new features include ACIS® 4.1 integration, multiple document interface, and photorealistic rendering. The Windows 95/NT software includes a new STEP™ translator that allows import and export of CAD data using the STEP AP203 standards. The 2D/3D Smart Cursor enables users to automatically snap to points (end, center, midpoint, quadrants, 2D and 3D intersections) during model creation. Other features include an ACIS end-capping algorithm to extend surfaces in complex modeling situations. **Circle No. 742**

## Visual Data Analysis

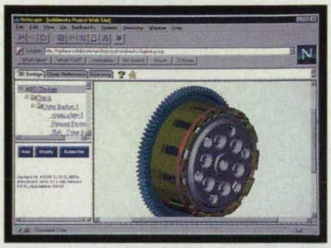
Visual Numerics, Boulder, CO, has introduced version 6.21 of its PV-WAVE visual data analysis (VDA) solution. New features include local language versions, internationalization, cross-platform visualization, improved Windows compatibility, and a pixmap device driver for creating PV-WAVE graphical output in memory. A new "century control" feature is designed to help developers circumvent Y2K problems in legacy PV-WAVE code. Other features include improved Windows capability to enhance printing and allow standard use of Windows device drivers. **Circle No. 740**

## 3D From 2D




AutoZ from EMT Software, Bellingham, WA, is a new program for AutoCAD Release 14 that creates 3D solid models from 2D multiview drawings. The software analyzes lines and curves in a 2D drawing and sorts the geometry into views; it then builds a solid model inside the drawing and sets up a 3D viewpoint. The user can add or remove material from the solid by extruding, revolving, or intersecting profiles. The program is network-ready and Y2K-compliant, and loads automatically when used with AutoCAD R14 on Windows 95/NT. **Circle No. 743**

## Website Management

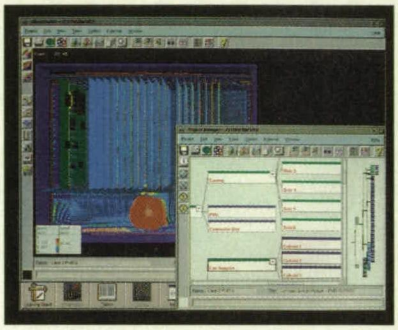


ActiveProject™ version 3.0 software from Framework Technologies Corp., Burlington, MA, enables project teams to organize, publish, manage, and communicate about engineering and related project information via corporate intranet, extranet, or the Internet. It consists of two products: ActiveProject Builder 3.0, a software tool featuring graphical drag-and-drop technology for visually organizing and publishing information on a Project Web Site; and ActiveProject Server 3.0, a Web server application that adds security and collaboration capabilities to sites created with ActiveProject. Features include user and information access control, real-time publishing, and user-initiated subscription and change notification. **Circle No. 745**

## Accessible 3D Viewing

3D View™ 2.5 from Actify Corp., San Francisco, CA, is a 3D CAD viewer that enables users to view and share 3D designs without having to purchase CAD software or hardware. The program supports viewing of SolidWorks™, IGES, STL, VDA, VRML, and ISO G Code files, and includes the ability to add measurements, multimedia notes, and real-time cross-sectioning. Users can save multiple views and include 3D models in office documents or Web pages. **Circle No. 741**

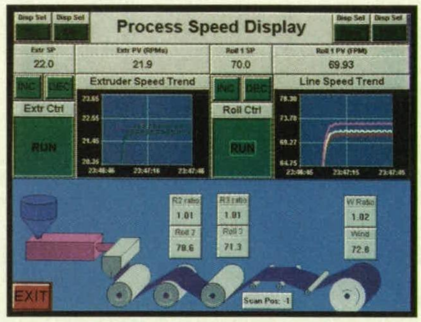
# New on DISK



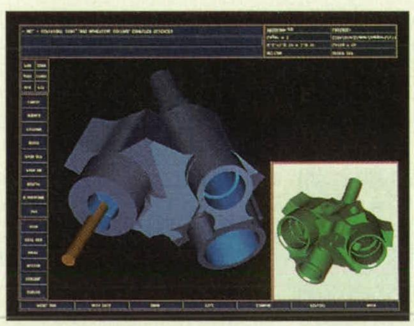
## Thermal-Analysis Software

Flomerics, Marlborough, MA, has announced Flotherm Version 2.0 electronic thermal-analysis software that allows the user to create, edit, and manipulate data in a CAD-like environment. The software has three main application windows: Project Manager gives a hierarchical view of the model; Drawing Board provides CAD-like geometry-creation capability; and the Visualization window provides advanced 3D graphics using the OpenGL standard. An advanced radiation model automatically calculates view factors between surfaces. The program also provides intelligent interpretation and simplification of geometry imported from MCAD software such as Pro/ENGINEER, I-DEAS, and Solid Designer. **Circle No. 744**

## Factory Automation Program

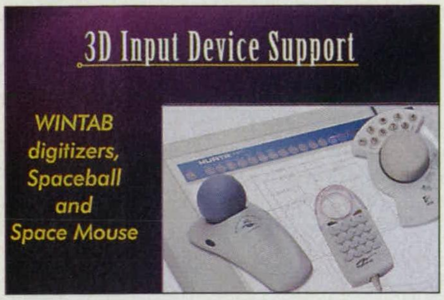



Deeco Systems, a business of Lucas Varity, Hayward, CA, offers Power Assist, an operator interface development tool for factory automation and data acquisition. The Windows software operates on standalone computers or in a network running Windows 3.x, 95, or NT. Graphical interface components — such as SPC, real-time trends, gauges, bar graphs, and image animation — are designed to facilitate process analysis and interpretation. Connectivity is upheld through DDE, NetDDE, ODBC, and dedicated I/O drivers (DDL) for specific equipment interfaces. Applications include power plants, polymer-film production, injection molding, and food/chemical/semiconductor processing. **Circle No. 747**



## Multi-Axis Machining Software

Numerical Control Computer Sciences (NCCS), Irvine, CA, has released V9.0 of its NCL multi-axis machining software. The CAM system generates simultaneous 2- through 5-axis NC tool paths and provides parametric 3D modeling. The program features an integrated NC verification module called NCL/IPV (In-Process-Verification), which incorporates a new technology designed to allow true solids verification. The solid model can be rotated and zoomed during the simulation process, resulting in an accurate solid model of the cut part which can be accurately inspected and then written into a number of standard formats including IGES and STL. **Circle No. 748**




## Support for Input Devices

SURFCAM Version 7.1 2D/3D mechanical design, surface modeling, solid modeling, NC programming, and multi-axis machining software from Surfware, Westlake Village, CA, includes a custom interface that supports 3D input devices, including the Spacetec Spaceball and the Magellan Space Mouse. The software also accommodates all 2D input tablets that use a WinTab-compatible driver. The operator can simultaneously use the digitizer puck and the computer mouse. SURFCAM also supports the generic ASCII file formats typically output by 3D digitizers, and offers a direct interface for interactive communication with the Faro digitizing arm. **Circle No. 749**

## Technical Publishing Tool

Waterloo Maple, Waterloo, ON, Canada, has announced MapleExplorer, a technical publishing tool that offers customized display of scientific and mathematical expressions and documents. It enables the user to experience live mathematics on the Internet through the combination of IBM's techexplorer Hypermedia Browser and Waterloo Maple's Maple V Release 5. MapleExplorer renders a large subset of TEX and LATEX markup languages for scientific documents and supports hypertext, multimedia, extended navigational features, and many user-definable User Interface features, such as pop-up menus. **Circle No. 750**


## Windows-Based Label Design

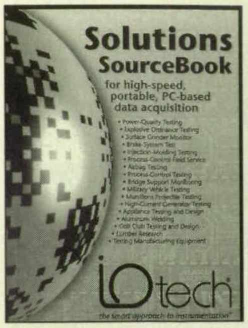
The Identifications Solutions Division of Brady USA, Milwaukee, WI, offers LabelMark™/WIN Windows™-based label-design software that is designed specifically for the electrical and telecommunications industries. The program offers mouse capability and clickable icons to help simplify label creation. Users can simultaneously view many labels as they are guided through printing, file creation, and label formatting. Applications include marking wires, cables, terminal blocks, control panels, and components; voice and data equipment labeling; rating plate identification; and asset identification. **Circle No. 751**

## Visual Development Software

Integrated Computer Solutions (ICS), Cambridge, MA, has introduced Builder Xcessory PRO 5.0 (BX PRO™ 5.0) integrated visual development product suite that allows UNIX developers to deploy their applications on multiple platforms, including the Web, Windows NT, Windows 95, and Windows 98. The program consists of Builder Xcessory™, an advanced graphical user interface builder for Java and Motif; ViewKit™, a C++ reuse framework that can be tailored to individual businesses; and EnhancementPak™, a library of 30 reusable components including business graphs and user interface controls. Platforms supported include UNIX systems from Sun, HP, IBM, DEC, and SGI. **Circle No. 746**

# New LITERATURE

## Portable Data Acquisition




The Solutions SourceBook from IOtech, Cleveland, OH, is a 32-page booklet consisting of 17 application notes describing how various test-and-measurement requirements were met using portable PC-based data acquisition systems. Topics include product-design evaluation, equipment testing, structure monitoring, and in-vehicle testing. Each application uses IOtech's WaveBook/512™, a portable, 1-MHz data acquisition system. **Circle No. 758**

## Engineering Software


A 45-page brochure from Bentley Systems, Exton, PA, describes the Bentley Continuum, a series of products and services addressing all stages of the engineering process. Included are MicroStation TriForma engineering software, ModelServer Continuum server software, MicroStation Modeler design software; and other design/manufacturing/engineering products. Services include Bentley SELECT, a service and technology subscription program; Bentley Consulting; and MicroStation Institute training centers. **Circle No. 760**

## Basic Instruments


Hewlett-Packard, Englewood, CO, has released a 60-page catalog describing basic instruments such as oscilloscopes, logic analyzers, data acquisition instruments, multimeters, function generators, counters, power supplies, RF products, and connectivity products. Also featured are cables and connectors, software options, and multifunction portables. **Circle No. 768**

## Transducer Delivery System


Sensotec, Columbus, OH, offers a four-page brochure on the FP2000 transducer delivery system. The brochure outlines this series of gage, absolute, and differential pressure transducers whose modular design allows them to be individually configured based on the needs of the application. Included are specifications, along with an ordering matrix to assist in selecting the correct configuration and price. **Circle No. 761**

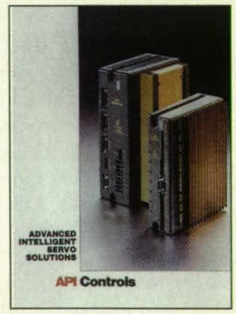
## Spring Manual


The Marsh Mellow® Spring Design Manual from Firestone Industrial Products, Carmel, IN, describes the hollow-centered, solid rubber and fabric spring designed to serve as a vibration and noise isolator for vibrating equipment, screens, shakers, grizzleys, feeders, and compactor tables. The manual includes selection information, dynamic characteristics and installation guidelines. **Circle No. 762**

## Pneumatic Valves


The N-263 pneumatic proportional valves from Herion USA, Warrendale, PA, are described in a four-page brochure. The valves are designed for control of air pressure and flow; applications include robotics, automated test stands, process control, and medical equipment. **Circle No. 763**

## Digital Servo Drives




API Controls, Amherst, NY, offers a 32-page brochure featuring three series of digital brushless servo drives. The Digital Drive series is for torque and velocity control using ±10 V analog or step-type commands and encoder feedback. The Intelligent Drive series includes positioning, programmable I/O, and resolver feedback capabilities. The Centennial series offers advanced features such as dynamic adaptive compensation and master/slave mode. **Circle No. 764**

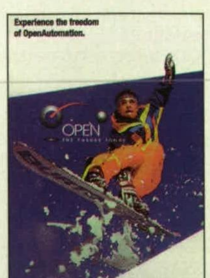
## Software Showcase


National Instruments, Austin, TX, has released a new version of its Software Showcase CD for Windows NT/95/3.1 and Macintosh. The CD provides information and demonstration versions of application software for measurement and automation, such as LabVIEW™ 5.0, LabWindows™/CVI 5.0, and HiQ™ 4.0. The CD is in standard HTML format and is available in Chinese, English, French, German, Italian, and Japanese. **Circle No. 765**

## Compressed-Air Products


A 72-page catalog from EXAIR Corp., Cincinnati, OH, offers solutions to common industrial cooling, blowoff, cleaning, drying, conveying, and static-electricity problems. Products include a quiet air knife, control-panel coolers, air-saving nozzles, tool coolers, vortex tubes, air-operated conveyors, industrial-housekeeping products, and static eliminators. Product descriptions include technical explanations, performance data, photos, illustrations, and dimensional drawings. **Circle No. 766**

## Automation Solutions




A 12-page brochure from Rockwell Automation, Milwaukee, WI, outlines the company's OpenAutomation solutions, which cover control technology, I/O, open networks, computers, and system software. Among the solutions are compact PC-based open controllers; industrial computers designed for the factory-floor environment; and SoftLogix™ 5 Controller, combining a Windows NT®-based controller with the PLC-5® technology. **Circle No. 767**

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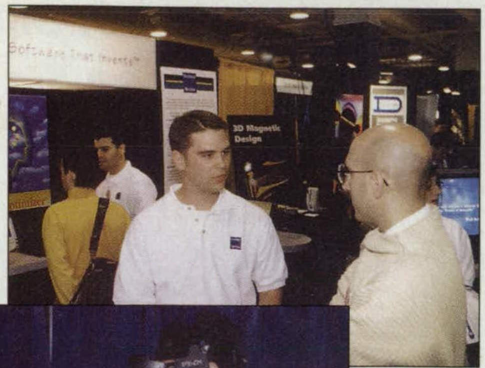



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